Willow Creek Subbasin

Temperature, pH and Bacteria Total Maximum Daily Loads and Water Quality Management Plan

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Prepared by:

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Major Contributors:

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Oregon Department of Fish and Wildlife
City of Heppner
US Army Corps of Engineers
Oregon Water Resources Department
USDA Natural Resource Conservation Service
Community volunteers

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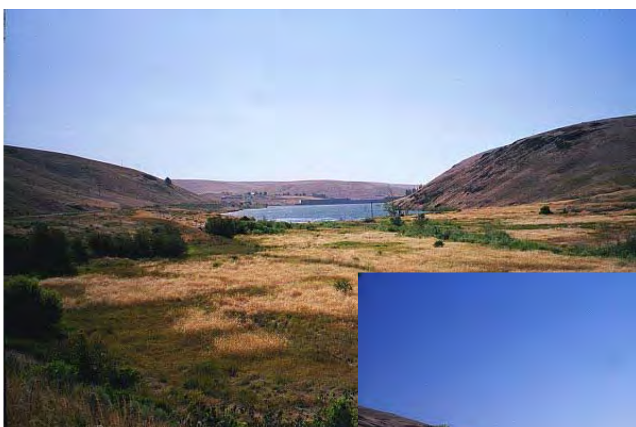


Willow Creek Reservoir

Willow Creek Valley Above Reservoir

Summary

This document lays out Total Maximum Daily Loads (TMDLs) and planning to address 303(d) listings for stream temperature, pH and bacteria in the Willow Creek Subbasin in Oregon. **Part 1** of this document is the policy expression of the TMDLs, **Part 2** the water quality management plan (WQMP) and the TMDL technical reports are included as appendices.

Subbasin 303(d) listings include: temperature for Willow Creek from the mouth to its forested headwaters, pH for Willow Creek below the Willow Creek Reservoir and bacteria for the Balm Fork. This report is issued through the Oregon Department of Environmental Quality (DEQ) and to US Environmental Protection Agency (EPA) as the TMDLs to address these listings. The TMDL analyses focus on the season(s) of concern for each pollutant.

Though supporting data are available from 1972 to 2005, TMDL-specific monitoring was conducted in the summers of 2000 and 2001. Due to resource limitations, several years have elapsed between the TMDL monitoring and preparation of this document. Current Information from point source permitting, recent water quality data from the Corps of Engineers and the City of Heppner and recent observations of vegetation and channel morphology have been incorporated to update this effort.

Willow Creek temperature, the most widespread listing, was simulated for 7/21/2000 to 8/9/2000. Existing and natural temperatures were assessed from the headwaters to the mid-lower basin. The simulated shade profile extends further, to the mouth, covering 120 kilometers (77 miles) of Willow Creek. The temperature assessment documents human-related stream heating associated with flow reduction, vegetation loss and channel widening. The goal of the temperature TMDL is a natural stream temperature pattern. Permitted facilities are assigned effluent limits. Diffuse sources are addressed through limits to solar radiant heat loading, which is also translated to effective shade. Other measures of progress are indicated as well.

Elevated ph in Willow Creek has historically resulted from Willow Creek Reservoir eutrophication and high withdrawal levels. A pH target is allocated to the Reservoir and is currently being met due to modified operations. Temperature can also be controlled by Reservoir operations. Though the Reservoir outflow is lower temperature than inflow, outflow does not meet the water quality standard (natural condition criteria) for temperature during August. A target temperature is issued via this TMDL to the Reservoir. The Reservoir is operated by the US Army Corps of Engineers (USACE).

Willow Creek's Balm Fork, the stream listed for bacteria, receives a load allocation for *E. coli*. Based on low counts of bacteria in the headwaters of neighboring basin streams and the low density of residential or urban development in the Balm Fork watershed, natural sources seem unlikely to account for the high levels of bacteria in the system. The land use for Balm Fork is agricultural and rural residential – both are addressed through the Senate Bill 1010 agricultural planning process. Septic issues are addressed through DEQ and County on-site rules.

There are two individual-facility National Pollutant Discharge Elimination System (NPDES) permitted discharges in the Subbasin, both on Willow Creek near Heppner: the City of Heppner municipal sewage treatment plant and the Oregon Co-Gen power generating plant. These point sources are described in this report and are issued wasteload allocations (WLA). These allocations address temperature, pH and limit nutrient loading to existing levels.

Part Two of this document is a framework water quality management plan laying out the expectations for sector specific TMDL Implementation Plans from TMDL designated management agencies (DMAs). These organizations are asked to submit TMDL Implementation Plans within 18 months of the date of TMDL issuance.

TMDL Background

Waters of the State of Oregon are monitored by the DEQ and other agencies. This information is used to determine whether water quality standards are met, and consequently, whether beneficial uses of waters are fully supported. Section 303(d) of the CWA calls for a list of water quality limited waters and requires the establishment of a pollutant total maximum daily load (TMDL) for each water body of concern. DEQ is responsible for assessing data, compiling the 303(d) list and developing TMDLs. Both the list and TMDLs are submitted to EPA for approval. TMDLs are assessments that determine the maximum amount of pollutant that can be present in a water body while meeting water quality standards. This *loading capacity* can be allocated to *point*, *nonpoint* and future sources of pollution. Uncertainty and natural pollutant sources are accounted for as well. *Point sources* are those associated with discrete human-made conveyances such as pipes from waste water treatment plants (WWTP). *Wasteload allocations* are the portions of TMDLs attributed to point sources. *Nonpoint sources* are diffuse sources such as field runoff or excess solar radiation. *Load allocations* are the portions of TMDLs attributed to nonpoint sources, either natural or human. TMDLs are implemented via water quality management plans or administrative rules and procedures and, for point sources, permits issued through the NPDES program.

Geographic Scope

The TMDLs and management plan herein address the Willow Creek Subbasin [Hydrologic Unit Code (HUC) 17070104] including all current 303(d) listings in the Subbasin (2004/2006) 303(d) list.

Implementation and Adaptive Management

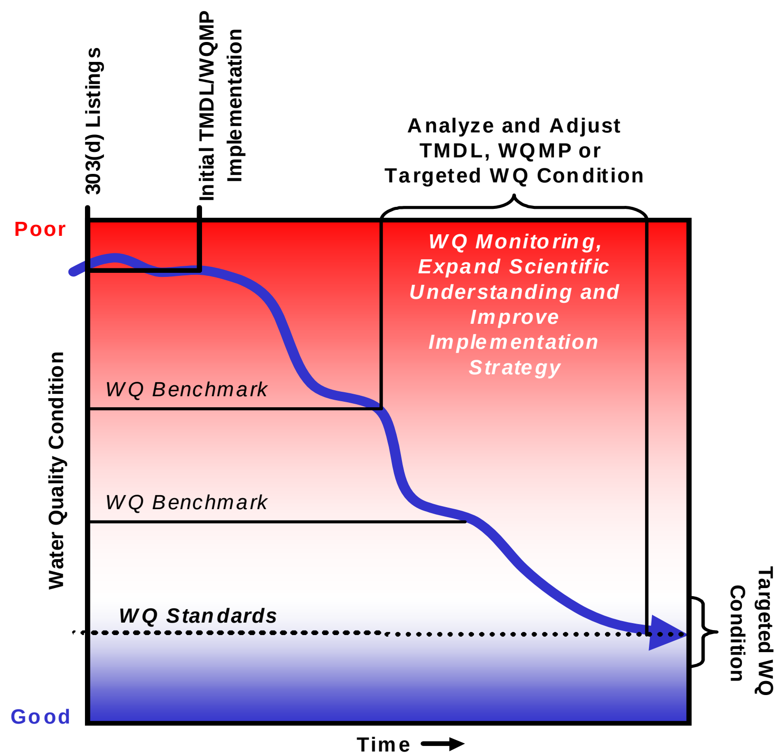
The WQMP directs management organizations to prepare planning leading toward TMDL attainment. Designated management agencies include: Oregon Department of Agriculture (ODA), the US Forest Service (USFS, Umatilla National Forest), the Oregon Department of Forestry (ODF) and the US Army Corps of Engineers. The form of response varies by organization. Some are governed by existing inter-agency agreements. DMAs are expected to respond in accordance with a timeline specified in **Part 2** of this document. TMDL Implementation Plans, specific to land use or water quality authorities, are the usual form of documentation addressing nonpoint source TMDLs. Normally existing programs are utilized.

The goal of the Clean Water Act and associated Oregon Administrative Rules (OAR) is to ensure that water quality standards are met or that all feasible steps are taken towards achieving the highest quality water attainable. DEQ recognizes that some improvement will require decades to fully manifest, particularly where nonpoint sources are the main concern. To achieve this goal, implementation should commence as soon as possible.

To clarify the Department's expectations, the following is acknowledged with regard to TMDLs and their implementation:

- The TMDL process occurs in ongoing cycles, based on implementation effectiveness, the availability of information, new 303(d) listings and the state of understanding of watershed and management processes. DEQ recognizes that TMDL allocation attainment is not always feasible. This can be due to large margins of uncertainty or socioeconomic constraints. Limitations should be stated in Implementation Plans and evaluation of feasible measures is important in these instances. For example, where conditions such as riparian vegetation or stream channel geometry are TMDL objectives, DEQ encourages adaptive re-assessment of channel and vegetation potential. Also, technology and programs for controlling nonpoint source pollution are evolving. It is possible that repeated management approaches may be key to success.

- Reduced stream heating often requires minimization of riparian disturbance. That said, the purpose of the TMDL is not to eliminate human activity in riparian areas. It is DEQ's expectation, however, that designated agencies will address how management will achieve the allocations.
- DEQ also recognizes that at various times and locations attainment of estimated natural conditions may be impeded by natural disturbance. The definition of *natural conditions* in rule includes: "…Disturbances from wildfire, floods, earthquakes, volcanic or geothermal activity, wind, insect infestation, diseased vegetation are considered natural conditions" (OAR 340-041-0002(34)).
- Full TMDL attainment at all locations may not be feasible due to physical, legal or regulatory constraints. To the extent possible, the Implementation Plans should identify potential constraints, but should also provide the ability to address those constraints as new opportunities arise. For instance, at this time an existing bridge may preclude attainment of channel potential and not be slated for reconfiguration due to feasibility issues. In the future, should the bridge undergo repair or modification, consideration should be given to designs that support TMDL implementation.
- The Federal Advisory Committee on TMDLs (**Committee Report, EPA 1998**), EPA and DEQ expect reasonable assurance of implementation. DEQ envisions that substantial initiative exists to achieve water quality goals in Oregon. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers to overcome impediments through education, technical support, and as a last resort where appropriate, enforcement.
- DEQ anticipates that each management agency will monitor and document its progress in implementing the provisions of its Implementation Plan. This information will be provided to DEQ for TMDL review.
- Where implementation of TMDL planning or effectiveness of management techniques is found to be inadequate, DEQ expects management agencies to revise planning or benchmarks to address these deficiencies (see graph below).



Adaptive Management - Schematic Diagram.
WQ – water quality, WQMP – water quality management plan

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Part One:

Total Maximum Daily Load Elements

Willow Creek Reservoir

Willow Creek Valley Above Reservoir

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Environmental
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1.1 Introduction

Water quality standards are designed to protect all designated beneficial uses of waters of the state including recreation, drinking water supply and fisheries. TMDLs establish the maximum level of pollutant allowable in order to meet water quality standards. **Part 1** of this document lays out TMDLs, addressing stream temperature, pH and bacteria levels. The Willow Creek Subbasin TMDLs will be implemented through the *Water Quality Management Plan* (WQMP) of **Part 2**. As implementation proceeds, the TMDLs will be re-visited as needed to address progress and new information regarding management effectiveness, limitations and water quality processes.

Part 1 is organized based on the list of elements in Oregon TMDLs according to rule (OAR 340-042). A checklist prepared by the US Environmental Protection Agency (EPA 2002) provides further guidance for TMDL content. **Table 1.1-1** identifies the relationship between the two lists.

Table 1.1-1. *Relationship between State and Federal identification of key TMDL elements*

<table>
<tr><th>Oregon Administrative Rule (340-042)</th><th>EPA Checklist</th></tr>
<tr><td>(a) Name and Location</td><td>Scope of TMDL</td></tr>
<tr><td>(b) Pollutant Identification</td><td rowspan="2">Applicable Water Quality Standards and Numeric Targets</td></tr>
<tr><td>(c) Water Quality Standards and Beneficial Uses</td></tr>
<tr><td>(d) Loading Capacity</td><td>Loading Capacity</td></tr>
<tr><td>(e) Excess Load</td><td></td></tr>
<tr><td>(f) Sources or Source Categories</td><td></td></tr>
<tr><td>(g) Wasteload Allocations</td><td>Wasteload Allocations</td></tr>
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<tr><td>(j) Seasonal Variation</td><td>Seasonal Variation</td></tr>
<tr><td>(k) Reserve Capacity</td><td></td></tr>
<tr><td>(l)(j) Reasonable Assurance*</td><td>Reasonable Assurance (if wasteload allocations depend on load allocations)</td></tr>
<tr><td>OAR 340-042-0050 Public Participation</td><td>Public Participation</td></tr>
<tr><td colspan="2">For additional clarification relating narrative and numeric water quality standard criteria, DEQ typically prepares an additional section ‘Water Quality Standard Attainment Analysis.’</td></tr>
</table>

*in Water Quality Management Plan

The text of **Part 1** draws frequently on the technical appendices. In addition to providing analytical methods and data summaries, the appendices include further discussion of scale, Subbasin description, heating processes, pH controls, analytical limitations and other information.

1.2 Subbasin Description, Facilities and 303(d) Listings

Willow Creek Subbasin physiographic features and town sites are shown in **Figure 1.2-1**, including the principal water bodies relevant to this document.

Figure 1.2-1. *Major water bodies and towns of the Willow Creek Subbasin*

Willow Creek is the mainstem of the Subbasin, a relatively narrow artery for its length of roughly 130 km (81 miles). It flows from the western Blue Mountains to the Columbia River between the towns of Arlington and Boardman, Oregon. Much of the Subbasin is shrub-steppe and the upper ten percent is forested. The Subbasin land area is approximately 228,000 hectares (880 square miles), with elevation ranging from 80 to 1740 meters (260 to 5700 feet) and lower basin stream flow varying annually from zero to more than 142 cubic meters per second [(5,000 cubic feet per second (CFS)]. Rainfall ranges from low to moderate. The land cover is primarily related to agriculture and forest, with minor areas of urbanization comprising the cities of Heppner, Ione and Lexington. Land area is mostly privately owned. Agricultural land use occupies by far the greatest area. The population density is generally low. Land use, cover and ownership are mapped subsequently in this Section. The major tributaries of Willow Creek, from the top down, are Herren, Shaw, North Fork, Balm Fork, Hinton Creek, Rhea Creek and Eightmile Creek.

Water quality standards are aimed at sensitive beneficial uses, for any given type of impairment, thus protecting all designated uses. Salmonids are particularly sensitive to temperature. Resident redband trout live above the reservoir and elsewhere in the Subbasin. In the Oregon water quality standard for temperature, the Willow Creek Subbasin is designated with redband trout as the focal sensitive use. The pH standard is also based on cold-water fish such as salmon and trout. The fresh water bacteria standard is based on water contact recreation, and it is noted that the Balm Fork, where excess bacteria has been measured, drains into Willow Creek Reservoir, where recreational use is common. Designated beneficial uses for the purpose of water quality standards are listed in **Table 1.2-1**.

Table 1.2-1. *Designated Beneficial Uses, Umatilla Basin, including Willow Creek Subbasin (OAR 340-41-0310, Table 310A). Note that the Willow Creek Subbasin is part of the Umatilla Basin and adjacent to the Umatilla Subbasin.*

Beneficial Uses	**Umatilla Subbasin**	**Willow Creek Subbasin**
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X (at mouth)
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	X
Commercial Navigation & Transportation		

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.
[2] See also Figures 310A and 310B for fish use designations for this basin.

Structural alterations to Willow Creek include straightening, re-location, levees, irrigation diversions, fish passage impediments, road crossings and the Willow Creek Reservoir. Below the coniferous upper watershed, the absence of shade-producing riparian vegetation is common and this is largely related to human activities. Data evaluation reported in this document (**Appendices D, E and F**) indicates that nonpoint source impacts are clearly the dominant water quality concern in the Subbasin. During the low flow period (late July through September) of recent decades, the lower 30 to 45 miles of Willow Creek exhibits a dry streambed with isolated reaches of pools or springs. It is probable that this lower reach was historically intermittent (historic record, **Appendix D**), but with less withdrawal summer surface flow would reach further downstream. Water quality conditions leading to elevated pH and temperature are exacerbated due to low summer flow in Willow Creek. **Figure 1.2-2** displays an array of flows in July through September.

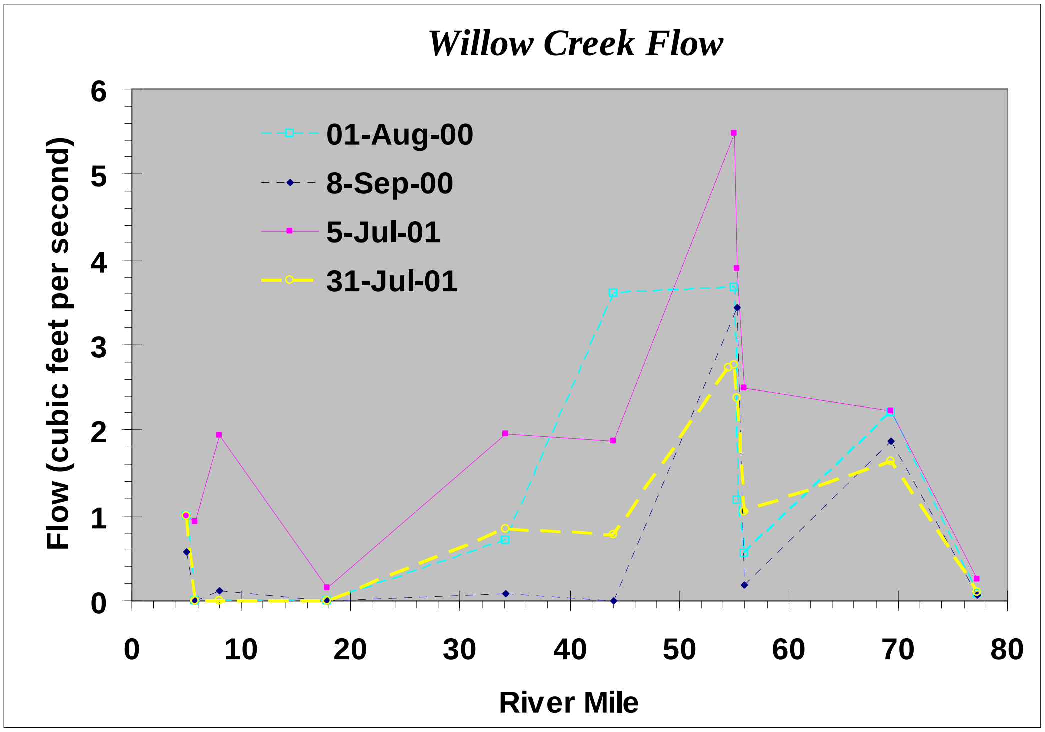


Figure 1.2-2. *Measured flow in Willow Creek during the 2000-2001 monitoring (DEQ) – portable flow meter.*

The Subbasin 303(d) listings are shown in **Table 1.2-2**. The listings for Willow Creek are for temperature and pH. The temperature listing extends from the mouth upwards and into the forested headwaters. The pH listing is for Willow Creek below the reservoir. The remaining listing in the Subbasin is for bacteria on Balm Fork.

Table 1.2-2. *Willow Creek Subbasin 303(d) listings.*

Record ID	Waterbody Name	River Mile	Parameter	Season	List Date
5262	Balm Fork	0 to 9.5	Fecal Coliform	Summer	1998
5260	Willow Creek	0 to 51.7	pH	Summer	1998
5071	Willow Creek	0 to 51.7	Temperature	Summer	1998
5072	Willow Creek	51.7 to 72.6	Temperature	Summer	2002

Table note: the list has been updated for 2004/2006. Temperature is now listed as River Mile 0 to 72.7, year around (Non spawning) - Redband or Lahontan cutthroat trout: 20.0 degrees Celsius (ºC) 7-day-average maximum; added to the 393(d) database in 2004.

Further discussion of climate and physiography can be found in **Section 1.5** of **Appendix D**. The following subsections describe locations for various landmarks, monitoring sites and tributaries; specific facilities; and basin land use, cover and ownership.

Location Reference

Throughout this document there are many charts and references to river kilometer and river mile. **Figure 1.2-3** illustrates the relationship between the two, with familiar geographic reference sites shown.

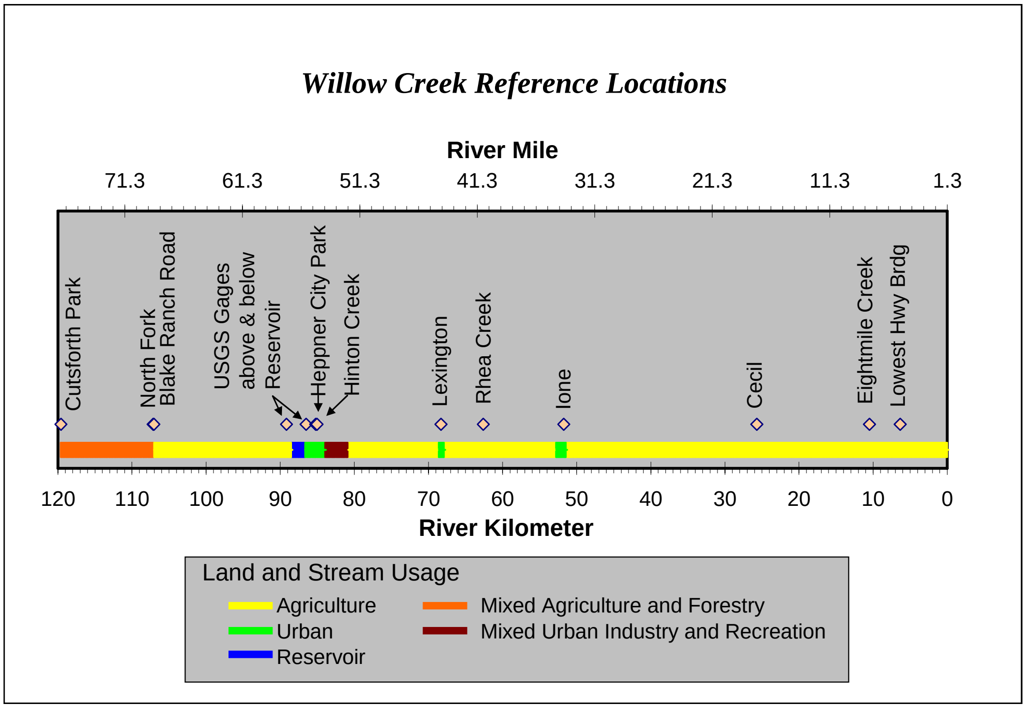


Figure 1.2-3. *Locations referenced by kilometer and river mile. It should be recognized that the above mileage is imprecise due to river change and varying mapping methods. However, temperature model input and output for simulations of temperature, effective shade and hydrology are precisely referenced at 50-meter intervals based on ortho-imagery (current aerial photographs in GIS). Because of this the kilometer scale is more explicit. The downstream origin (1.3 km south of I-84) of 50-meter model input nodes is shown in **Figure D1-2b of Appendix D**.*

Stream gaging stations provide an important dataset for TMDLs, typically providing daily average stream discharge measurements. United States Geological Survey (USGS) gage stations are operated, and have been for many years, for Willow Creek above and below the Willow Creek Reservoir (**Figures 1.2-3 and 1.2-4**) and at the mouth of the Balm Fork of Willow Creek. Other gages were operated historically.

Willow Creek Reservoir

The Willow Creek reservoir, built in 1980-1983, is an impoundment on Willow Creek just above Heppner, and maintains a salient role in controlling flow, pH and temperature. The physical features of the reservoir and dam are described in **Table 1.2-3**. **Figures 1.2-1** and **1.2-3** illustrate the Reservoir's location. Both Willow Creek and Balm Fork Creek flow into the Reservoir.

In late July and early August, the reservoir typically released around 0.008 cubic meters per second (CMS, 3 CFS) during the 2000-2001 TMDL monitoring whereas beginning in 2003 and to the present, the outflow during August ranged from 0.23 to 0.56 CMS (8 to 20 CFS). The increase serves new irrigation rights to Reservoir-stored water. Irrigation was one of the original purposes of the reservoir in addition to flood control and recreation, though many years elapsed between Reservoir construction and rights applications. Another important change of recent years is the installation of an aeration system by the

USACE in 2004, to address low oxygen conditions in the lower levels of the reservoir. Air is released at depth through twelve control discs located at the lake floor. The rising air promotes vertical mixing of the water column, which formerly manifested strong pH and temperature gradients (both decreasing down). The aeration system continuous operation time frames during the first two years of operation were June 14 – November 22, 2004 and March 15 – October 27, 2005.

There are two primary controls influencing water quality in the reservoir outflow – the aeration system and withdrawal depth. The aeration system is described in the previous paragraph. Withdrawal depth is controlled by Reservoir outlets. Willow Creek Dam has two outlets for discharging Reservoir water: (1) a low-level regulating conduit [12 CMS (420 CFS) maximum] and (2) a depth-selective withdrawal mechanism, referred to as a water quality outlet [(2.7 CMS) (95 CFS) maximum]. The water-quality outlet can selectively withdraw water ranging from elevations of 321 to 632 meters (2037 to 2076 feet). The pool elevation ranges from 617 to 629 meters (2025 to 2063 feet), so the withdrawal level can range from 0 to 8 meters (0 to 26 feet) below the surface, depending on pool surface elevation. The low-level outlet is a separate outlet which withdraws from an elevation of 605 meters (1984 feet, Larson, 1997). Currently the selective withdrawal mechanism is set for 5 meters (17 feet) below the surface (personal communication with Jim Britton, USACE Portland Office).

The USACE has conducted Willow Creek Reservoir water quality studies over many years (Larsen, 1997 and data reported directly to DEQ by Jim Britton, USACE Portland office). These studies substantially inform the analysis reported in this document, and are discussed in **Appendices D-F**.

Table 1.2-3. *Dimensional characteristics of Willow Creek Dam and Lake (USACE 1983, 1986, 1988, 1990) from Table 1 in Larson (1997)*

Dam	
length, feet	1,780 (542.5 m)
maximum height, foundation to crest, feet	160 (48.8 m)
crest elevation, feet	2,129 (649 m)
crest width, feet	16 (4.88 m)
volume, $feet^3 \times 10^6$	10.9 (308,134 m^3)
design capacity, $feet^3$/sec. x 10^3	93 (2,642 m^3/sec.)
outlet capacity at pool elevation 2047 feet, $feet^3$/sec.	501 (14.2 m^3/sec.)
Lake	
length, miles	0.982 (1.58 km)
maximum controlled pool elevation, feet	2,113.5 (644.2 m)
maximum pool elevation, feet	2,063.0 (628.8 m)
minimum pool elevation, feet	2,047.0 (623.9 m)
storage capacity at maximum controlled pool elevation, acre-feet	14,089 (17.4 X $10^3 m^3$)
storage capacity at maximum pool elevation, acre-feet	4,325 (5.3 X $10^3 m^3$)
storage capacity at minimum pool elevation , acre-feet	2,539 (3.1 X $10^3 m^3$)
surface area at maximum controlled pool elevation, acres	267.9 (1.084 km^2)
surface area at maximum pool elevation, acres	126.0 (0.510 km^2)
surface area at minimum pool elevation, acres	95.1 (0.385 km^2)

Permitted Point Sources

There are two individual-facility NPDES permitted discharges in the Subbasin, both on Willow Creek near Heppner: the City of Heppner municipal sewage treatment plant and the Oregon Co-Gen power generating plant. The locations of these facilities are portrayed in **Figure 1.2-4**. Facility locations, identification and characteristics are described below.

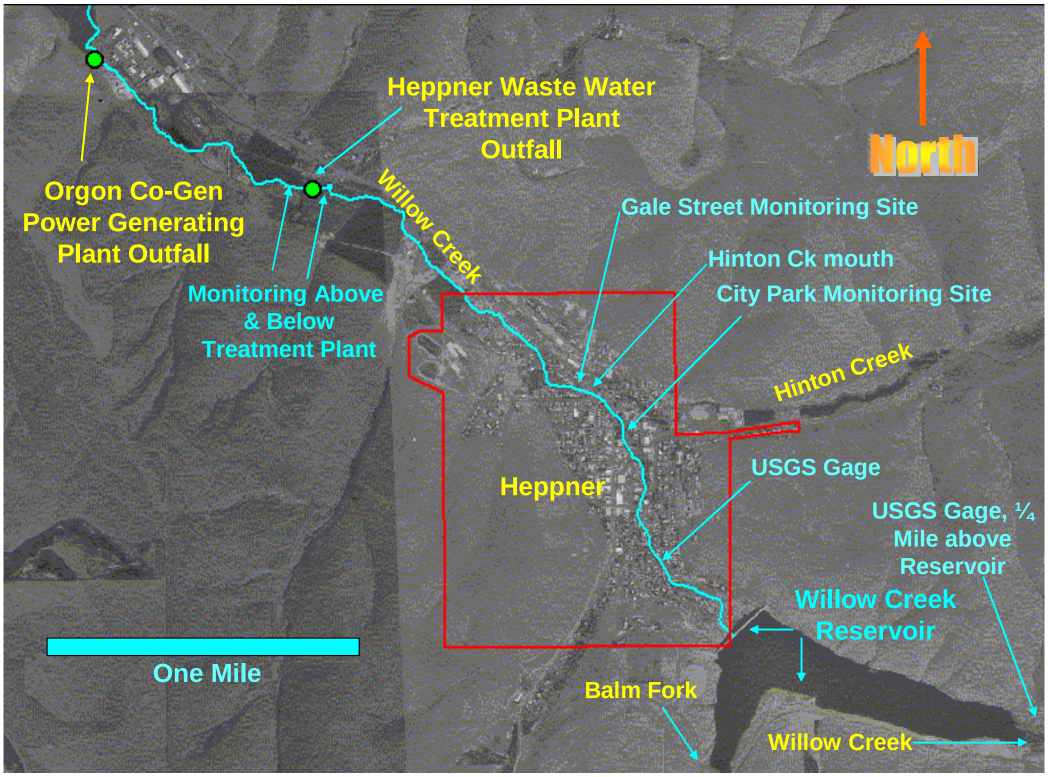


Figure 1.2-4. *Aerial photograph of Heppner area showing permitted point sources of waste water discharge to Willow Creek. Key monitoring sites are shown with blue arrows.*

Identification and Description of City of Heppner Waste Water Discharge

Facility Name: City of Heppner Waste Water Treatment Plant
EPA Reference Number: OR-002077-0
Permit Type: NPDES Individual-facility
Receiving Water Body: Willow Creek
Location: Heppner, Oregon
Discharge Mechanism: Pipe
Permitted Time Frame: Year Round
Effluent Maximum Limits (May 1 – October 31)

- **pH:** 9.0
- ***E. coli.*:** 126 organisms/deciliter log mean (5 samples), 406 organisms/deciliter individual sample
- **Other:** There are permit limits as well for BOD, TSS and Chlorine

Dry Weather Design Flow: 0.25 million gallons/day (0.39 cubic feet per second)
Facility Description: The facility is a municipal sewage treatment plant utilizing trickling filter treatment of liquid effluent. Effluent is either land applied to a golf course or an alfalfa field, or directly discharged to Willow Creek, or both. During much of the summer little or no effluent is discharged to Willow Creek.
Operational Status: Operational

Table 1.2-4 lists effluent characteristics for the Willow Creek outfall of the Heppner Waste Water Treatment Plant.

Table 1.2-4. *Nutrient monitoring data for Willow Creek, Balm Fork , Willow Creek Reservoir and City of Heppner Waste Water Treatment Plant*

Other Site Descriptions	Date	NO2+NO3 (mg/l as N)	Ammonia (mg/l as N)	Ortho-P (mg/l as P)	DIN (mg/l as N)	DIN/Ortho-P
Heppner Waste Water Treatment Plant Effluent	8/9/2001	9.25	5.70	2.65	14.95	5.64
Heppner Waste Water Treatment Plant Effluent	10/9/1999	10.70	5.20	2.57	15.90	6.19
Heppner Waste Water Treatment Plant Effluent	10/2/2005		1.00			
Heppner Waste Water Treatment Plant Effluent	11/2/2005		1.16			
Heppner Waste Water Treatment Plant Effluent	12/6/2005		2.80			
Heppner Waste Water Treatment Plant Effluent	1/4/2006		2.10			

Identification and Description of Oregon Co-Gen Generating Plant Waste Water Discharge

Facility Name: Oregon Co-Gen Power Generating Plant
EPA Reference Number: OR003152-36
Permit Type: NPDES Individual-facility
Receiving Water Body: Willow Creek
Location: Heppner, Oregon
Permitted Time Frame: Year Round
Effluent Maximum Limits

Temperature (not yet renewed for current standard)**:** After mixing with 0.25 degrees Fahrenheit (ºF) allowance (0.14 ºC) , 55 ºF (12.8 ºC) during January through June, 64 ºF (17.8 ºC)during July through September
pH: 9.0
***E. coli.*:** No limit specified in permit (not expected to be a source)
Other: There are permit limits as well for TDS, TSS, Chromium, Zinc, PCBs and Chlorine

Peak Flow of Process Water Discharge: This can range from 0.122 million gallons/day (0.189 cubic feet per second) at 4 cycles to 1.69 million gallons/day (2.62 cubic feet per second) at 1.2 cycles (from Feb 2004 permit evaluation of rapid infiltration modification, see discussion of cycling below).
Facility Description: The facility is a wood-chip fired steam electric power generating plant located at the former Kinzua Resources Lumber Mill one mile downstream from Heppner. It was adapted from an earlier power plant at the mill, which closed down in 1994. The earlier plant operated as a co-generation facility to generate electricity and supply steam for drying kilns. In 2001, the Port of Morrow reconditioned it with the expectation of marketing electrical power. However, because of issues with electrical prices and technical problems, it ran only intermittently through 2003 and has been inactive during much of 2004 and 2005. When operational, three waste water streams are produced, boiler water blowdown, cooling water blowdown and water softener regeneration waste water. The combined discharge enters a detention pond prior to final disposal. The detention pond receives the combined boiler system effluent. From the pond, effluent is discharged either directly to Willow Creek, or indirectly to Willow Creek via a pilot project rapid infiltration gallery located approximately 8 meters (25 feet) from the bank of Willow Creek. The infiltration gallery is 46 meters (150 feet) downstream from the direct discharge outfall. Facility design allows flexibility in discharging most or all of the effluent through either mechanism. The rapid infiltration gallery is expected to further cool waste water from the detention pond. Facility domestic sewage is discharged to a septic tank and drain field.

Oregon Co-Gen uses ground water to feed the boiler and cooling water systems. Prior to use, boiler feed water is treated to control mineral accumulation and corrosion in the equipment. Cooling water is chlorinated to control algae growth and recycled 1.2 to 4 times before blowdown. This cycling largely controls the rate of water usage and discharge.
Operational Status: Not currently operating (see above)

The NPDES permit for the City of Heppner requires monthly monitoring reports to be submitted to DEQ. Temperature and pH are measured several times per month, supporting analysis of potential stream impacts in relation to the TMDL. These data and their evaluation are discussed in the **Section 1.4** and **Appendix E** of this document.

The Oregon Co-Gen Generating Facility has been re-conditioned and permitted recently (September 2001 is the original permit date, for the first individual-facility NPDES permit) and therefore does not have a long monitoring record to inform the TMDL assessment. This is particularly true of the latest facility modification – addition of a rapid infiltration basin in 2003 as a pilot project for indirect discharge to Willow Creek. Accordingly, some of the information is estimated, based on engineering studies (Cascade Earth Sciences, 2003) and permit evaluation (February, 2004). The Department requires a water quality analysis report (not yet received) for the facility and rapid infiltration basin that will provide additional basis for determining compliance with water quality standards, including comparative data for monitoring wells and Willow Creek downstream from the infiltration basin.

Tables 1.2-5 through **1.2-6** list expected facility effluent characteristics for the Oregon Co-Gen Generating Plant prior to consideration of the rapid infiltration gallery. **Tables 1.2-7** through **1.2-8** include the expected influence to Willow Creek after infiltration through the gallery and mixing with Willow Creek (excerpted from Cascade Earth Sciences, 2003).

Table 14. Summary of Discharge Quality Characteristics - pH
Port of Morrow Generating Plant - Heppner, Oregon

Month	2003[1] Average	Max.	Min.	Reference[2] Average
	---------- s.u. ----------			
Jan	8.39	9.37	7.87	8.39
Feb	7.95	8.40	7.09	7.95
Mar	8.44	8.73	7.88	8.44
Apr	8.29	8.87	7.61	8.29
May	8.46	8.67	8.19	8.46
June	8.25	8.83	7.21	8.25
Jul	8.47	8.60	8.28	8.47
Aug				8.32
Sep				8.32
Oct				8.32
Nov				8.32
Dec				8.32
Average	8.32	8.78	7.73	8.32

NOTES:
[1]Source: Port of Morrow discharge monitoring station at Heppner Generating Facility.
[2]Represents the average discharge characteristics for months with sampling data and the average discharge condition of the previous months' data for months without sampling data.
"Max" = Maximum average value for a 24-hr period.
"Min" = Minimum average value for a 24-hr period.

Table 1.2-5. *{Table 14 in Cascade Earth Sciences (2003)}. Monthly 2003 pH summary of effluent samples before spraying into the rapid infiltration gallery.*

Table 15. Summary of Discharge Quality Characteristics - Temperature
Port of Morrow Generating Plant - Heppner, Oregon

Month	2003[1] Average	2003[1] Max.	2003[1] Min.	Reference[2] Average
	---------- °F ----------			
Jan	51.09	56.49	43.54	51.09
Feb	50.89	65.12	46.66	50.89
Mar	60.92	68.26	51.23	60.92
Apr	58.63	65.50	52.84	58.63
May	57.93	59.37	56.71	57.93
June	53.88	62.16	46.25	53.88
Jul	61.94	66.22	57.68	61.94
Aug				56.47
Sep				56.47
Oct				56.47
Nov				56.47
Dec				56.47
Average	**56.47**	**63.30**	**50.70**	**56.47**

NOTES:

[1]Source: Port of Morrow discharge monitoring station at Heppner Generating Facility.

[2]Represents the average discharge characteristics for months with sampling data and the average discharge condition of the previous months' data for months without sampling data.

"Max" = Maximum average value for a 24-hr period.

"Min" = Minimum average value for a 24-hr period.

Table 1.2-6. *{Tables 15 in Cascade Earth Sciences (2003)}. Monthly 2003 temperature summary of effluent samples before spraying into the rapid infiltration gallery.*

Table 24. Projected pH Impacts - Conservative Conditions with 7Q10 Stream Flows[1]
Port of Morrow Generating Plant - Heppner, Oregon

Month	Discharge[2]		Groundwater[3]		Post-Mixed Groundwater[4]		Stream[5]		Post-Mixed Stream[6]	
	Flow	pH	Flow	pH	Flow	pH	Flow	pH	Flow	pH
	gpm	s.u.	gpm	s.u.	gpm	s.u.	gpm	s.u.	gpm	s.u.
Jan	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
Feb	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
Mar	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
Apr	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
May	100	8.5	6.1	6.9	106	8.4	1,125	8.9	1,231	8.9
Jun	100	8.5	6.1	6.9	106	8.4	1,125	9.2	1,231	9.1
Jul	100	8.5	6.1	6.9	106	8.4	1,125	9.0	1,231	8.9
Aug	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
Sep	100	8.5	6.1	6.9	106	8.4	1,125	8.8	1,231	8.8
Oct	100	8.5	6.1	6.9	106	8.4	1,125	8.3	1,231	8.3
Nov	100	8.5	6.1	6.9	106	8.4	1,125	8.1	1,231	8.1
Dec	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7
Average	100	8.5	6.1	6.9	106	8.4	1,125	8.7	1,231	8.7

NOTES:

[1]Assumes maximum discharge flow, minimal groundwater mixing, and 7Q10 stream flow.

[2]Assumes peak flow at 100 gpm and high pH based on data from Table 14.

[3]Assumes discharge will mix with groundwater flow through 3' upper profile directly beneath RI system at 50' wide. Flow calculated as cross-section area of 150 ft2 x average hydraulic conductivity @ 415 ft/d x original gradient @ 0.019 ft/ft (refer to Table 6). Average pH based on data from Table 7.

[4]Resulting parameter calculated as discharge flow x discharge concentration + groundwater flow x groundwater concentration divided by total combined flow.

[5]Assumes 7Q10 flow and reference pH based on data from Table 9.

[6]Resulting parameter calculated as post-mixed groundwater flow x post-mixed groundwater concentration + stream flow x stream concentration divided by total combined flow of stream and post-mixed groundwater.

Table 1.2-7. *{Table 24 in Cascade Earth Sciences (2003)}. Reported conservative pH mixing model calculations for effluent entering Willow Creek from rapid infiltration gallery. Conservative assumptions include: peak process flow, low hydraulic conductivity estimate, mixing only with the upper 3-feet of aquifer. The Department notes that linear mixing of pH seems to have been assumed – further evaluation has been requested of the facility.*

Table 25. Projected Temperature Impacts - Conservative Conditions with 7Q10 Stream Flows[1]
Port of Morrow Generating Plant - Heppner, Oregon

Month	Discharge[2]			Groundwater[3]			Post-Mixed Groundwater[4]			Stream[5]			Post-Mixed Stream[6]		
	Flow	Temp.	Heat Load	Flow	Temp.	Heat Load	Flow	Temp.	Heat Load	Flow	Temp.	Heat Load	Flow	Temp.	Heat Load
	gpm	°F	kJ/m	gpm	°F	kJ/m	gpm	°F	kJ/m	gpm	°F	kJ/m	gpm	°F	kJ/m
Jan	100	48.0	14,103	6.1	55	1,237	106	48.4	15,340	1,125	41.4	93,060	1231	42.0	108,400
Feb	100	47.6	13,751	6.1	56	1,290	106	48.1	15,041	1,125	41.3	91,788	1231	41.8	106,830
Mar	100	52.0	17,629	6.1	58	1,398	106	52.3	19,027	1,125	45.5	133,475	1231	46.1	152,502
Apr	100	55.0	20,274	6.1	60	1,506	106	55.3	21,779	1,125	49.5	173,751	1231	50.0	195,530
May	100	58.8	23,623	6.1	62	1,613	106	59.0	25,236	1,125	62.5	302,551	1231	62.2	327,788
Jun	100	62.1	26,532	6.1	64	1,721	106	62.2	28,253	1,125	65.3	330,218	1231	65.0	358,471
Jul	100	65.6	29,573	6.1	65	1,774	106	65.5	31,347	1,125	65.2	329,326	1231	65.2	360,673
Aug	100	64.4	28,559	6.1	64	1,721	106	64.4	30,280	1,125	65.4	331,607	1231	65.3	361,887
Sep	100	62.4	26,796	6.1	62	1,613	106	62.4	28,410	1,125	59.3	270,550	1231	59.5	298,959
Oct	100	55.0	20,274	6.1	60	1,506	106	55.3	21,779	1,125	52.9	207,056	1231	53.1	228,835
Nov	100	49.4	15,337	6.1	58	1,398	106	49.9	16,735	1,125	47.8	157,077	1231	48.0	173,812
Dec	100	42.0	8,815	6.1	56	1,290	106	42.8	10,105	1,125	41.2	90,738	1231	41.3	100,843
Average	100	55.1875	20,439	6.1	60	1,506	106	55	21,944	1,125	53.1	209,266	1231	53.3	231,211

NOTES:

[1]Assumes maximum discharge flow, minimal groundwater mixing, and 7Q10 stream flow.

[2]Assumes peak flow at 100 gpm and average expected temperature based on data from Table 19.

[3]Assumes discharge will mix with groundwater flow through 3' upper profile directly beneath RI system at 50' wide. Flow calculated as cross-section area of 150 ft^2 x average hydraulic conductivity @ 415 ft/d x original gradient @ 0.019 ft/ft (refer to Table 6). Average temperature based on data from Table 7.

[4]Resulting temperature calculated as total combined heat load from discharge and groundwater divided by total flow converted to corresponding temperature.

[5]Assumes 7Q10 flow and reference temperature based on data from Table 10.

[6]Resulting temperature calculated as total combined heat load from post-mixed groundwater and stream divided by total flow converted to corresponding temperature.

Table 1.2-8. *{Table 25 in Cascade Earth Sciences (2003)}. Conservative temperature mixing model calculations for effluent entering Willow Creek from rapid infiltration gallery. Conservative assumptions include peak process flow, low hydraulic conductivity estimate, mixing only with the upper 3-feet of aquifer.*

Population, Local Government and Land Use

The largest population centers in the Subbasin are the incorporated Cities of Heppner, Ione and Lexington, with populations of 1,410, 340, 260, respectively. Willow Creek flows through each.

The upper, southern part of the Subbasin is within the Umatilla National Forest. The USFS is the only large federal landholder adjacent to Willow Creek. The US Bureau of Land Management (BLM) oversees areas in the lower part of the Subbasin. Whereas the USFS manages land along miles of upper Willow Creek, BLM land only occupies approximately 460 meters (1500 feet) of stream length.

Land ownership and land use are portrayed in **Figures 1.2-5** through **1.2-7**. Land ownership relative areas are listed in **Table 1.2-9**.

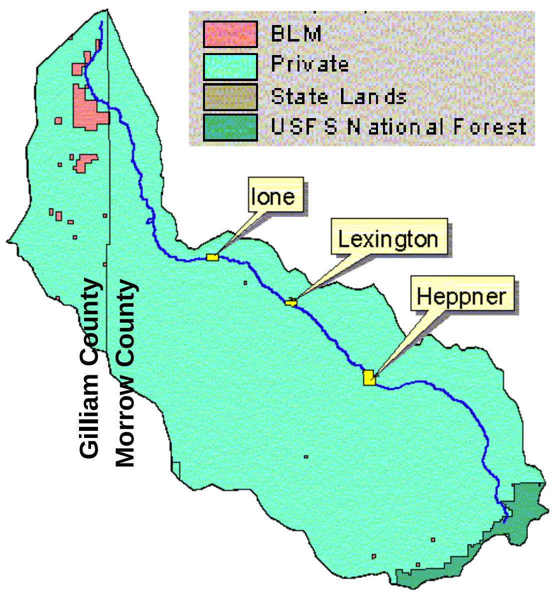


Figure 1.2-5. *Willow Creek Subbasin land ownership shown in gross categories (Oregon Geographic Information Center, 1999)*

Ownership or Management	Percent
Private (including urban)	96.3
Umatilla National Forest	2.3
US Bureau of Land Management	1.3
State Lands of Oregon	0.0063

Table 1.2-9. *Willow Creek land ownership in percentage of Subbasin area*

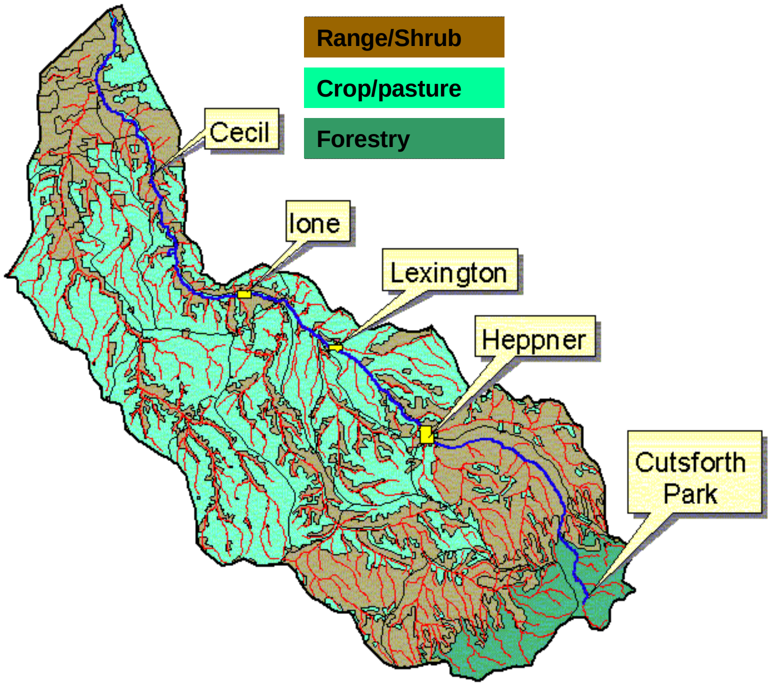


Figure 1.2-6. *Willow Creek Subbasin land use shown in gross categories (Oregon Geographic Information Center, 1999). Various place names are shown for location reference.*

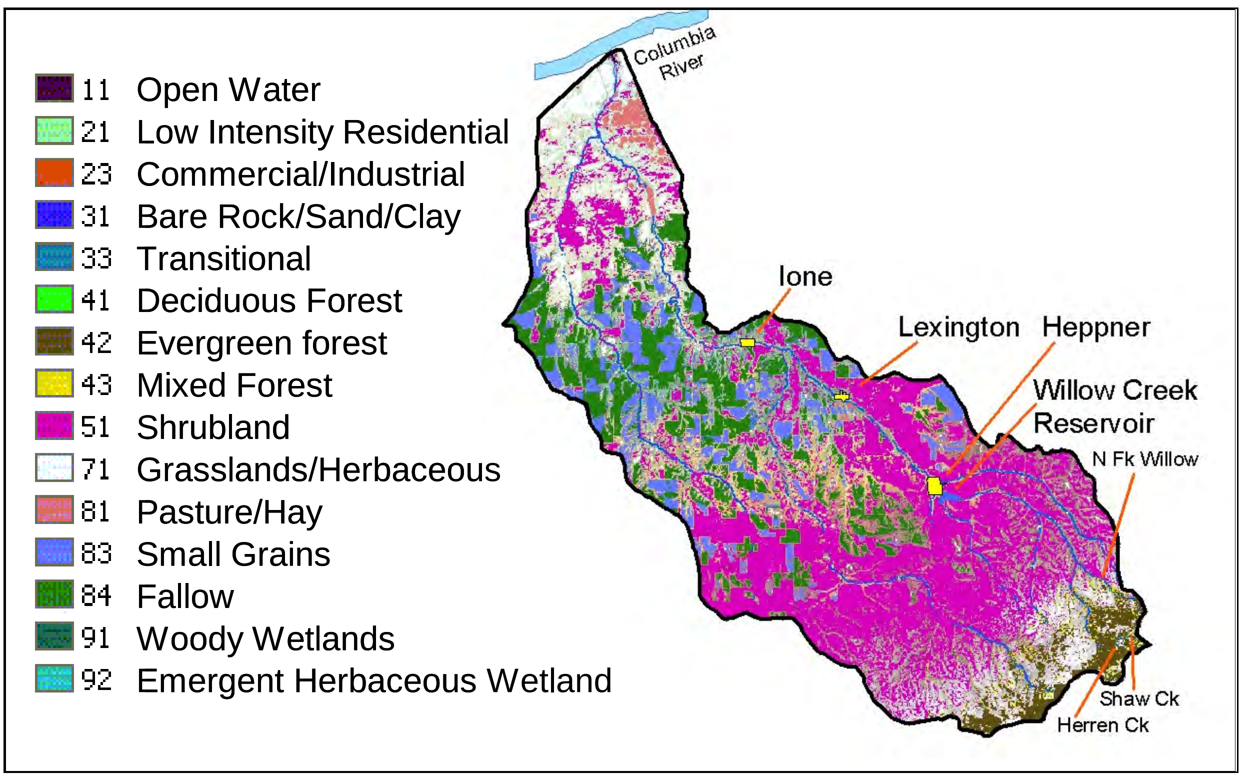


Figure 1.2-7. *Willow Creek Subbasin land cover (National Land Cover Data, 2000)*

1.3 TMDL FOR TEMPERATURE

Table 1.3-1 below summarizes the temperature TMDL.

Table 1.3-1. *Temperature TMDL Summary Information*

Water bodies	Willow Creek Subbasin, Hydrologic Unit Code #17070104: Willow Creek and all other Subbasin streams that are perennial or have natural potential to be perennial.
Water Quality Standard	Oregon stream temperature standard (OAR 340-341-0028, approved by EPA March, 2004)
Applicable Water Quality Standard Criteria	Natural condition criteria of OAR 340-041-0028(8)
Target Pollutant / Loading Capacity	Heat / solar radiation heat loading from natural thermal potential conditions (nonpoint source). Heating via mass transfer (point sources).
TMDL Surrogate	Percent effective shade (**Figure 1.3-4**)
Related Measures of Progress	Diel temperature range, others (**Table 1.3-5**).
Existing Pollutant Sources	Nonpoint source vegetation reduction and channel alteration (agriculture, flood control, forestry, urban, transportation). NPDES point sources. Willow Creek Reservoir.
Margin of Safety	Implicit – optimal conditions are targeted, and conservative assumptions are incorporated into modeling.
Reserve Capacity	None

(1.3a) Name, Location and 303(d) Listings

This Chapter defines the temperature TMDL for the Willow Creek Subbasin. Oregon TMDLs are being developed at the subbasin or basin scale. The 303(d) listings, water bodies of concern and subbasin Hydrologic Unit Code for the Willow Creek subbasin are identified in **Section 1.2**.

From the 2004/2006 303(d) list recently submitted to EPA, the listing criteria and season are “Redband or Lahontan cutthroat trout: 20.0 degrees – (68.0 ºF) 7-day-average maximum, year around (non-spawning).”

(1.3b) Pollutant and Target Identification

Change in water temperature is an expression of heat energy transfer per unit volume. The *nonpoint source pollutant is heat originating from human-caused increases in solar radiation* received by streams. The *point source pollutant is heat in the form of warm water discharge* to surface waters.

Terminology Note: *Point sources* of pollution are discharges via localized human-made conveyances. For example, a city waste water treatment plant is a point source. *Nonpoint* sources of pollution are diffuse sources such as field runoff or excess solar radiation.

The Oregon water quality standard for temperature includes biologically based temperature targets. Computer simulation of heating of Willow Creek indicates that these criteria are not attainable in much of the subbasin in the summer even at conditions approaching natural (**Appendix D**). In such situations, the temperature standard (next section) specifies that ***the target of the TMDL is "natural thermal potential (NTP) temperatures"*** [OAR 340-041-0028(8)] with a 0.3 ºC (0.5 ºF) human use allowance [(HUA, OAR 340-041-0028(12)(b)(B)].

Though recently developed capabilities for estimation of solar heating are robust, estimates of natural temperatures are limited by practical difficulties in assessing groundwater influence/changes and some of the influences of increased sinuosity. Given these limitations, a best approximation is made by assessing solar heating in relation to channel and vegetation geometry and surface flow. Improved flow and riparian conditions sets the stage for channel evolution and shading that ultimately lead to natural temperatures, particularly if management allows for restoration of other stream functions as well, such as floodplain recharge and increased sinuosity.

The NTP, the evaluation of which is discussed in detail in **Appendix D**, refers to the best estimate of vegetation, channel shape, stream flow and other thermal controls that would occur without past and present human disturbance. ***The NTP channel and vegetation geometry are the basis for the heat load allocations of this TMDL***. Temperatures are simulated for various flow profiles as well. Hence the TMDL addresses the applicable water quality criteria – the 'natural condition criteria.' Potential channel width and depth, vegetation and flow were simulated along the entire length of Willow Creek. As discussed in **Appendix D**, the lower part of Willow Creek [below river kilometer 46 (mile 30)] is not included in the NTP temperature estimation, though heat loads are calculated. This is because there was insufficient flow in the lower mainstem to provide sufficient model validation for temperature. In this lower reach, temperature differences between various scenarios are likely accurate, but absolute temperatures should be considered rough estimates. However the radiant heat load allocations are valid throughout the profile. The assessment of solar heat flux is not dependent on flow.

The highest stream temperatures in the subbasin occur 2:00 PM – 5:00 PM in late July and early August. Accordingly, afternoon temperatures of this time frame are the focus of temperature discussion and illustration in this document. **Figure 1.3-1** illustrates the estimate of natural thermal potential afternoon temperature for the modeled corridor, based on NTP during the height of summer. The model time frame is July 21-August 9, 2000. Staffing and resource limitations have prevented earlier analysis, however ongoing acquisition of flow data has enabled model scenarios addressing later year increased flow (**Appendix D**), and ground surveys were conducted in 2005 and 2006 to confirm that the land cover has not changed significantly in since 2000.

It is noted that, where analysis has been conducted, present and future NPDES point sources are also subject to the natural condition criteria. Outside of the time interval of NTP assessment, they would be held to the biologically based criteria of the temperature standard. The other elements of the temperature standard generally apply as well, such as the mixing zone requirements (OAR 340-041-0053).

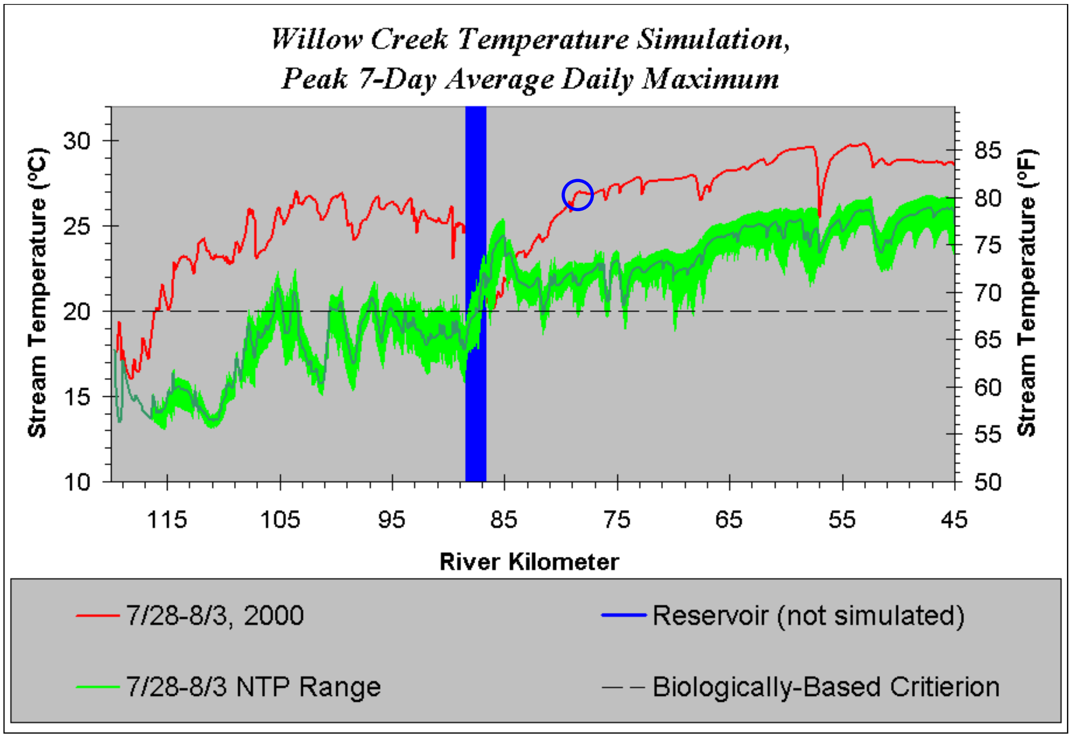


Figure 1.3-1. *{Recall of Figure 4-12 in Appendix D} Peak seven day rolling average of the daily maximum temperatures for summer 2000 and NTP temperature simulation. The upper model scenario (red line) represents the existing condition (July 28 to August 3, 2000), including flow rates. The light green band and dark green line represent the range and midpoint of natural potential vegetation height estimations, respectively. The blue circle indicates a point of maximum impact below WLA facilities in the Heppner vicinity. For location reference - river miles, key locations and tributaries are related to river kilometers in **Figure 1.2-3**.*

Human Use Allowance

As mentioned earlier in this section, the temperature standard provides for a human use allowance (HUA): "…a cumulative increase of no greater than 0.3 ºC (0.5 ºF) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact" {OAR 340-041-0028 (12)(a)(B)}.

Along the modeled corridor, the "point of maximum impact" is where the greatest difference between existing and NTP temperatures occur below certain human-related heat sources. The blue circle in **Figure 1.3-1** at river kilometer 78.2 (mile 50) is drawn at the first local maximum difference below the lowermost facility receiving a temperature limit via this TMDL.

The HUA would not significantly influence general nonpoint source objectives (radiant heat load allocations). In the nonpoint source context, the value is small enough to be masked by uncertainty associated with instream measurement and modeling software. For this reason, a human use allowance is not assigned to nonpoint sources. And because no new NPDES permit application has been received by the Department and the area population has changed little over the years, no part of the HUA is set aside as reserve for future growth. A HUA can be significant with regard to the two existing point source discharges, and possibly the Reservoir, and is entirely set aside for these three facilities.

The HUA allotted for each facility is 0.2 ºC (0.36 ºC), based on the cumulative effects analysis of **Section 4.5** of **Appendix D**. As evaluated in **Appendix D**, facilities must be restricted to 0.2 ºC, rather than 0.3 ºC (0.5 ºF), because simulation indicates the potential for thermal overlap of approximately 0.1 ºC (0.18 ºF). For example, if the Heppner WWTP increased the stream temperature by 0.3 ºC, under critical conditions 0.1 ºC would remain un-dissipated as the flow reached the Co-Gen plant. If the Co-Gen plant increased the stream temperature by 0.3 ºC, then the stream would, for a short distance below the Co-Gen plant, have been heated by 0.4 ºC (0.62 ºF) by the cumulative influence of the two sources – whereas the maximum cumulative increase allowable under OAR 340-041-0028 (12)(b)(B) is 0.3 ºC. An individual-facility allowance of 0.2 ºC each prevents a cumulative increase in excess of 0.3 ºC.

Addressing Stream Flow

The water quality standard defines the TMDL target of *natural thermal potential* as "the determination of the thermal profile of a water body using best available methods of analysis and the best available information on the site potential riparian vegetation, stream geomorphology, stream flows and other measures to reflect natural conditions" (OAR 340-041-0002(35)). The stream flow component of this definition is distinct from the others, in that flow effects aren't readily described in terms of target pollutants. Also, the CWA specifically states: "…nothing in this Act shall be construed to supersede or abrogate water rights to quantities of water which have been established by any state…" (Section 101(g)). The reader should note that DEQ is not the State authority for managing or regulating water quantity and distribution.

This may seem paradoxical – one rule targeting natural temperatures and related flows in a TMDL; and policy and jurisdictional limitations on doing so. And there's the reality that flow influences temperature. In order to resolve this, DEQ bases the TMDL allocations on solar radiant heat per unit stream surface area – such an allocation is not flow dependant. The resultant temperatures *are* flow dependant, and are simulated for a range of flows, including a natural flow estimate. Flow however, is not allocated. The natural flow-based temperature profile provides information. Restoration strategy development should benefit from this and the NTP temperature profile provides for point source temperature limits and long term evaluation of water quality standard attainment.

Existing and NTP flow profiles for Willow Creek are portrayed in **Figure 1.3-2** for a selected date. Assessment and derivation of these and other profiles are described in **Appendix D**.

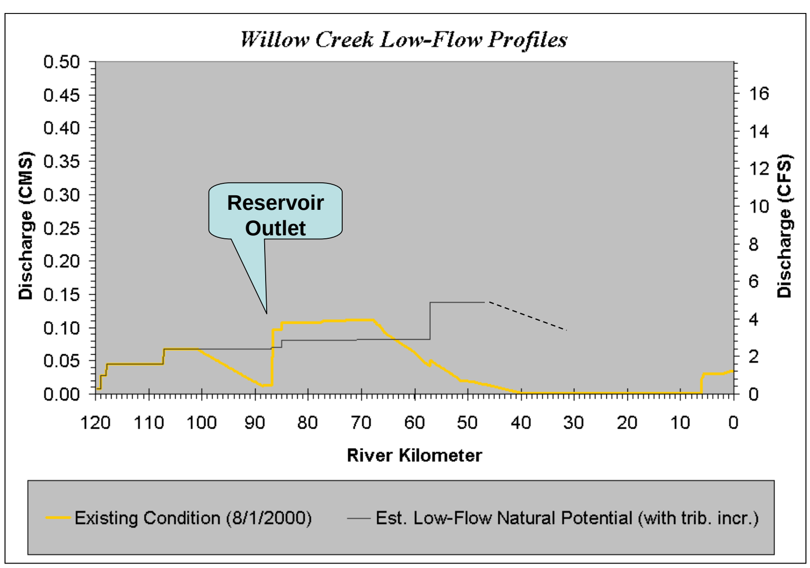


Figure 1.3-2. *{Recall of Figure 3-18 in Appendix D} Existing and NTP flow profiles for Willow Creek*

In Willow Creek, flow restoration is underway. Irrigators have applied for stored water from the Willow Creek Reservoir. Currently, higher-than-natural flows exit the Willow Creek Reservoir during the warmest part of the summer.

Intermittent stream flow in lower Willow Creek. Temperature was simulated for the lower reaches of Willow Creek to inform flow restoration. Given that it's not known how far natural continuous flow could extend down Willow Creek, modeling was implemented the full distance from headwaters to mouth. As described elsewhere, because of the roughness of calibration in the lower section, NTP temperatures are not specified. The site specific shade allocations are applicable for the length of Willow Creek including its lower reaches downstream to the mouth, even though vegetation characteristics are influenced by flow availability, because it is not known how far natural low flow would extend downstream. The Department recognizes that intermittent flow may lead to a reduced level of natural potential vegetative shade in this lower section, and will adjust the LA objectives as the system evolves and is better understood.

Point Sources and Willow Creek Reservoir

There are two individual-facility NPDES sources in Willow Creek Subbasin, the City of Heppner WWTP and the Oregon Co-Gen power generation facility 1.7 kilometers (one mile) below the WWTP. Facility details are provided in **Part 1**, **Section 1.2**. The Willow Creek Reservoir, just above the City of Heppner, is also described in **Section 1.2**. The Reservoir and both point sources receive target temperatures and heat loads in this TMDL. Target temperatures are evaluated in **Appendix D** (**Section 4.5**), and recalled here:

Excerpt from Section 4.5, Appendix D (for conversion from recent assessed river kilometer to nominal river miles, refer to **Figure 1.2-3**. Note that 20 ºC is equivalent to 68 º F.)

Target Criteria

In the Willow Creek Subbasin, natural condition criteria vary spatially as shown in **Figure D4-12** and are of particular significance to individual facility NPDES discharges and the Willow Creek Reservoir. **Table D4-6** lists natural condition criteria simulation outcomes, specific to each of these key facilities or locations. As discussed previously, the natural condition criteria are the applicable criteria. However, in each case the lower end of the range of NTP temperature simulation is indistinguishable, within analytical uncertainty (±1.6ºC, **Table D4-2**), from the otherwise applicable biologically-based criteria of 20 ºC. Given this narrow margin, the Department deems 20ºC to be the target criteria for each site, during the critical period (**Chapter 5.0**).

Table D4-6. *Natural thermal profile temperature simulation results at key locations*

Facility or Location	Distance from mouth of Willow Creek (model input node)	Simulation Range *(7-day average of daily maximum temperature for NTP, ºC)*
Power Generation Plant, EPA Reference # OR-003152-36	Kilometer 81.10	19.9 – 22.3
City of Heppner Waste Water Treatment Plant, EPA Reference # OR-002077-0	Kilometer 82.77	20.3 – 22.4
Willow Creek at Willow Creek Reservoir outlet	Kilometer 86.75	20.2 – 22.7

As described in the excerpt above, the applicable criteria during the critical period (critical period is defined in **Section 1.3j**) is the natural condition criteria. In the Heppner area, the natural condition criteria is equated to the biological-based criteria since they are indistinguishable, within analytical uncertainty.

(1.3c) Water Quality Standards and Beneficial Uses

In order to protect all designated beneficial uses, water quality standards are developed to protect the most sensitive beneficial use. The Oregon temperature water quality standard (OAR 340-041-0028) is based on protection of sensitive fish through various life phases. The biologically-based criterion for redband trout (20 ºC, 68 ºF) is generally applicable in Willow Creek Subbasin [OAR 340-041-0028(4)(e)]. Redband trout occur presently and historically in the Willow Creek Subbasin. The full list of designated beneficial uses is shown in **Recall Table 1.2-1**, below. **Figure 1.3-3** maps the most sensitive of these beneficial uses.

This criterion is graphically compared with river temperature patterns (refer to **Figures 1.3-1** and **Section 1.3j** for spatial and seasonal patterns). The criterion would not be met during the summer in much of the subbasin even at NTP conditions. As discussed in **Section 1.3b**, *NTP* is the best available approximation of a more natural condition. The temperature standard states "Where the Department (DEQ) determines that the natural thermal potential of all or a portion of a water body exceeds the biologically-based criteria in section (4) of this rule, the natural thermal potential temperatures supersede the biologically based criteria, and are deemed to be the applicable temperature criteria for that water body" (OAR 340-041-0028(8)). Once an NTP determination is made and is applicable to an entire stream, it applies even where reaches of that stream are colder than the numeric biologically based criteria.

Recall Table 1.2-1. *Designated Beneficial Uses, Umatilla Basin, including Willow Creek Subbasin (OAR 340-41-0310, Table 310A). The uses that are most sensitive to heat pollution are highlighted.*

Beneficial Uses	Umatilla Subbasin	Willow Creek Subbasin
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X (at mouth)
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	X
Commercial Navigation & Transportation		

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.
[2] See also Figures 310A and 310B of the standard for fish use designations for this basin.
Table produced November, 2003

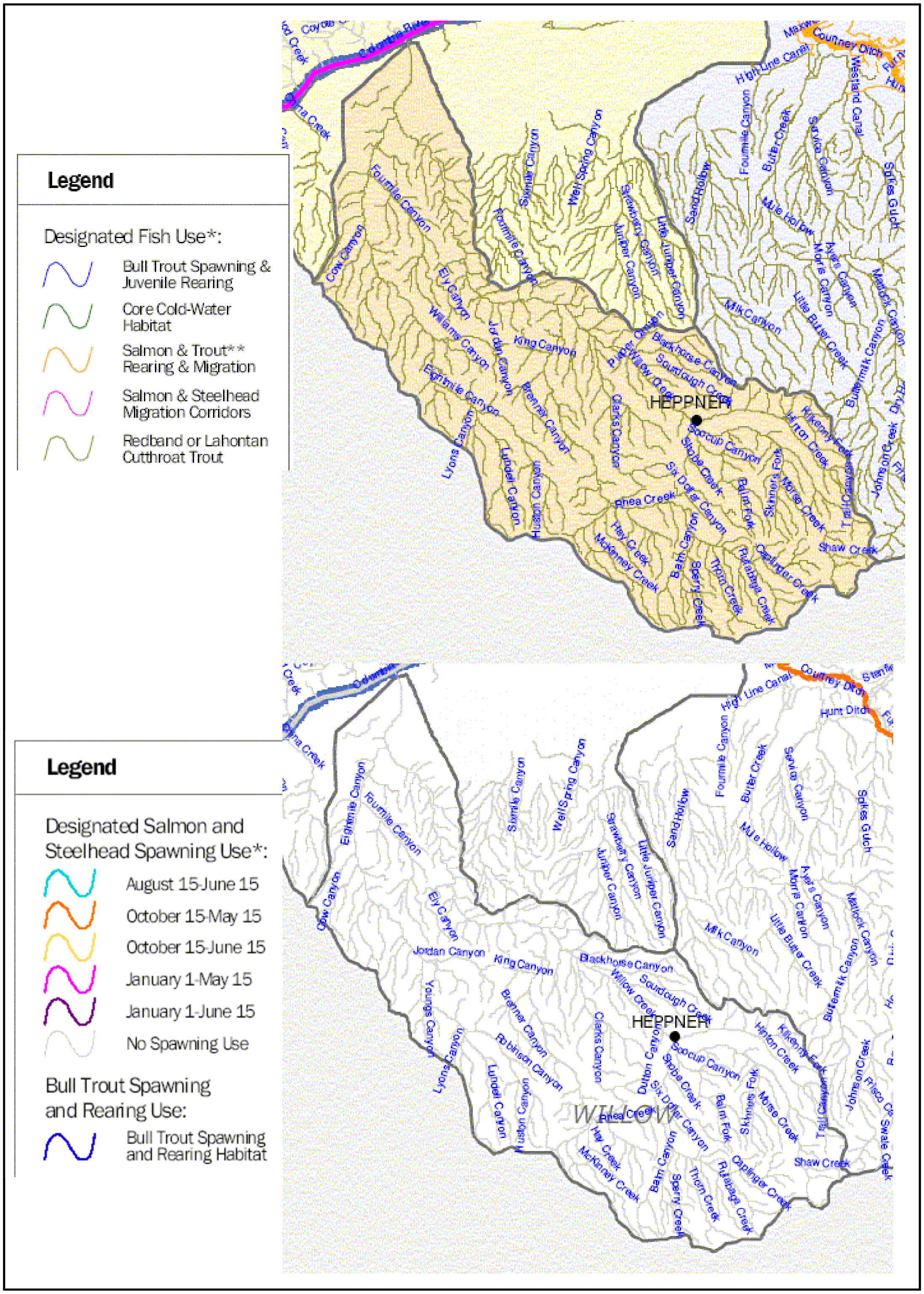


Figure 1.3-3. *Map of applicability for Water Quality Standard biologically based numeric criteria. Note that these plates are excerpted from larger maps – not all criteria in the legend are applicable in the Willow Creek Subbasin. These maps and further explanation are available at: http://www.deq.state.or.us/wq/standards/WQStdsTemp.htm.*

Additionally, the standard contains the text: "Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact" (OAR 340-041-0028(12)(b)(B)).

Accordingly, a natural thermal potential is the applicable criteria for this TMDL, to be met within 0.3 ºC at the point of maximum impact. This supersedes the biologically based criterion of OAR 340-041-0028(4) except at times and locations where the natural thermal potential has not been assessed or applied. The previous section (**1.3b**) elaborates further by discussing the following:

- NTP temperature estimation including graphical display
- the current points of maximum impact for the subbasin
- the application of the 0.3 ºC human use allowance
- the rule definition of *natural thermal profile* (under 'Addressing Stream Flow')

Additional components of the temperature standard are applicable to point sources, in the Mixing Zones Section, including the Thermal Plume Limitations section [OAR 340-041-0053(2)(d)]:

(d) Temperature Thermal Plume Limitations. Temperature mixing zones and effluent limits authorized under 340-041-0028(12)(b) will be established to prevent or minimize the following adverse effects to salmonids inside the mixing zone:

(A) Impairment of an active salmonid spawning area where spawning redds are located or likely to be located. This adverse effect is prevented or minimized by limiting potential fish exposure to temperatures of 13 degrees Celsius (55.4 Fahrenheit) or less for salmon and steelhead, and 9 degrees Celsius (48 degrees Fahrenheit) for bull trout;

(B) Acute impairment or instantaneous lethality is prevented or minimized by limiting potential fish exposure to temperatures of 32.0 degrees Celsius (89.6 degrees Fahrenheit) or more to less than 2 seconds);

(C) Thermal shock caused by a sudden increase in water temperature is prevented or minimized by limiting potential fish exposure to temperatures of 25.0 degrees Celsius (77.0 degrees Fahrenheit) or more to less than 5 percent of the cross section of 100 percent of the 7Q10 low flow of the water body; the Department may develop additional exposure timing restrictions to prevent thermal shock; and

(D) Unless the ambient temperature is 21.0 degrees of greater, migration blockage is prevented or minimized by limiting potential fish exposure to temperatures of 21.0 degrees Celsius (69.8 degrees Fahrenheit) or more to less than 25 percent of the cross section of 100 percent of the 7Q10 low flow of the water body.

(1.3d) Loading Capacity

Loading Capacity is defined as “the greatest amount of loading that a water can receive without violating water quality standards” (40 CFR 130.2(f)). The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. The nonpoint source heat loading capacity in the Willow Creek Subbasin is assessed as daily solar radiation heat loads based on NTP land cover and channel width. The point source component is the daily mass transfer stream heating rate allowed by the HUA. The loading capacity includes the sum of the two, here expressed in megawatts (MW).

The loading capacity can consist of several components:

$$LC = WLA + LA_{nps} + LA_{bkgd} + MOS + RC$$

Where:

LC = Loading Capacity
WLA = Wasteload Allocation (WLA)*
LA_{nps} = Load Allocation (LA)* from human nonpoint sources
LA_{bkgd} = Load Allocation* from natural background
MOS = Margin of Safety
RC = Reserve Capacity, for such as population growth or increased human loading

* the terms *Load Allocations* and *Wasteload Allocation* are defined in **Sections 1.3g** and **1.3h**

The Willow Creek loading capacity and its components are specified in **Table 1.3-3**. For further discussion of point sources, margin of safety and reserve capacity, refer to the applicable sections in this chapter (**1.3g**, **1.3i**, **1.3k**, respectively).

For Willow Creek from the mouth to Cutsforth Park (river kilometer 0-119.7), the nonpoint source component of the loading capacity is a maximum daily heating rate of 139 megawatts – the amount of solar energy that the stream is exposed to during late July and early August (**Section 4.2.6** of **Appendix D**). This is approximately equal to the bulk loading capacity because point source and Reservoir heating is slight in comparison (**Section 1.3g**). The nonpoint source component is translated into site-specific load allocations and other objectives (**Section 1.3h**).

Table 1.3-3. *Loading Capacity Distribution*

Loading Capacity in Modeled Corridor
Loading Capacity = 139 MW daily solar radiant heat loading + WLA (Note the solar and WLA heat are not entirely similar terms – to compare the temperature influence of each, the solar input would be adjusted for factors such as long wave radiation emission, evaporative heat loss and bed conduction – as is carried out in the TMDL temperature simulation portrayed in **Figure 1.3-1**)
Example WLA = 0.077 MW (daily maxima), assuming 3.0 CFS Willow Creek flow and 0.25 CFS effluent discharge (**Equation 4.5-2**, **Appendix D**)
LA_{nps} = 0
LA_{bkgd} = 139 MW daily solar radiation heat loading for NTP riparian and channel condition
MOS = 0 (implicit)
RC = 0

(1.3e) Excess Load

The 'excess load' element identifies the difference between the actual pollutant load in a water body and the loading capacity of that water body. The summer of 2000 heat loading was calculated for the various sources. Point sources are orders of magnitude lower than nonpoint sources (example in **Table 1.3-3**). Of the total heat exposure that occurs along the simulated part of Willow Creek, during the height of summer, fifty-seven percent (daily heat load equal to 183 megawatts) results from human activities (**Section 4.2.6** of **Appendix D**). The excess load is 183 MW on a given day during the warmest part of summer.

(1.3f) Pollutant Sources and Jurisdictions

As described in the preceding section, human-related summer heating in the subbasin has been found to be primarily *nonpoint source* heating. Using computer simulation, nonpoint source solar heating was evaluated by comparing the existing vegetation and channel with an estimate of undisturbed conditions. Substantial solar heating occurs due to the combined effects of reduced riparian vegetation height and density and increased channel width – both related to human activities. Point sources and the Willow Creek Reservoir were reviewed as well. Responsible parties for point sources and the Willow Creek Reservoir are as follows:

- Heppner Waste Water Treatment Plant – City of Heppner
- Power Generation Facility – Oregon Co-Gen, LLC
- Willow Creek Reservoir – US Army Corps of Engineers

Land use categories with activities that influence channel and vegetation structure are: agriculture, urban, forestry and transportation corridors. Agriculture comprises the largest area of land use in the Subbasin. Along the mainstem, roadways typically are not close enough to constrain channels or limit vegetative shading, except at some bridge crossings and in the uppermost watershed where the valley is narrow. The area of urban development is quite small. Coarse land use, cover and ownership maps are available in **Section 1.2** (main document). Basin description and development history are summarized in **Section 1.2** as well. **Figure 1.2-3** (main document) identifies existing land use adjacent to the mainstem.

Each mainstem segment highlighted in **Figure 1.2-3** has unique channel, vegetation and land use characteristics. These are summarized here beginning with the upper watershed and moving downstream. The upper mainstem from Cutsforth Park to the North Fork of Willow Creek is non-federal forest land. Vegetation disturbance in this area includes areas of harvest, treatment and road incursion. From the North Fork to Willow Creek Reservoir the valley bottom is used primarily for crops, hay and pasture with the highway distant from the Creek. In Heppner, Willow Creek is relatively shaded by trees and confined by urban development. Parts of this reach are entrenched. Between Heppner and river kilometer 42 below Ione, land use is primarily agricultural, the channel is wide and banks are generally absent of natural vegetation. The absence of trees and native vegetation is characteristic through much of the agricultural land along Willow Creek. Riparian buffers are almost non-existent and trees occupy roughly one percent of the stream length in these areas. Below river kilometer 42, the channel is assessed as more natural in width, but typically exhibits deep incision. Channel straightening and re-location are evident along much of the length of Willow Creek Below the North Fork.

Jurisdictions associated with the various nonpoint or diffuse pollutant sources identified in Willow Creek include:

Agricultural activities – Oregon Department of Agriculture
Non-Federal forestry – Oregon Department of Forestry
Umatilla National Forest – US Forest Service
Urban areas – incorporated municipalities

Solar radiation is the energy source driving daily stream heating. Solar radiation is directly influenced by channel and vegetation conditions as stated previously. In addition, streams manifest indirect causes of solar heating. Stream-straightening can be an indirect cause of solar heating. Straightening increases gradient, in turn increasing velocity and associated erosivity. This typically enlarges the channel, resulting in a wide and shallow stream, particularly during the low flow season. Bank weakening, by vegetation disturbance and associated loss of soil/root strength, similarly results in wide and shallow channels. Bank disturbance by livestock, vehicles and development generally leads to increases in stream width. A wide shallow stream is readily heated by the sun if not shaded. These situations are common in the Willow Creek Subbasin.

In contrast, summer daily temperature increases are less when ground water enters streams. The subsurface zone of water exchange between ground water and a stream is called the *hyporheic zone.* This zone, along with net ground water input to the stream, absorbs heat and directly cools stream water via mixing (in the summer subsurface water is generally cooler than stream water). Common causes of decreased groundwater input and exchange are: less floodplain area to collect spring floodwater, decreased sinuosity and associated reduction in bank area to transmit pore water, incision-lowered water tables, well withdrawal and decreased vegetative trapping and storage of precipitation and flood water. The type, amount and location of crop irrigation often influence groundwater patterns as well. In the Willow Creek subbasin, channel and floodplain modifications that contribute to loss of groundwater-stream interaction are readily observed.

(1.3g) Wasteload Allocations (point sources)

Wasteload Allocation is defined as "The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution" (40 CFR 130.2(h)).

Wasteload allocations are issued for the two individual-facility NPDES discharges in the subbasin – the City of Heppner WWTP and Oregon Co-Gen, LLC. Both facilities are in the Heppner vicinity. Facility description, specific locations and permit numbers are provided in **Section 1.2** (main document).

As noted in **Section 1.3b**, where appropriate analysis has been conducted, nonpoint sources and existing and future NPDES point sources are subject to NTP temperatures as maximum targets during the season of TMDL applicability. The time frame of TMDL applicability is described in **Section 1.3j**.

City of Heppner WWTP. The City of Heppner WWTP discharges year around, in two modes – direct discharge to Willow Creek and land application. Treated effluent is piped across Willow Creek to a water tank above the area golf course. It is then land applied to the golf course or alfalfa field during the growing season, and any excess is discharged to Willow Creek via a pipe running underground through the golf course. The facility dry weather design flow is 0.25 million gallons per day (0.39 cubic feet per second). The effluent discharge to Willow Creek is generally much less than this during the summer, due to consumption through land application.

The wasteload allocation for the Heppner WWTP is expressed as a daily Willow Creek heating rate, issued as an equation (**Equation 4.5-2**, **Section 4.5**, **Appendix D – excerpt below**). The heating rate is expressed in megawatts, and is dependant upon the HUA, effluent discharge and river flow. The HUA for the treatment plant is 0.2 ºC (0.36 ºF), as discussed in **Section 1.3b** of **Part 1**.

Excerpt from Section 4.5, Appendix D

Eq. 4.5-2: $H_{WLA} = (HUA)(Q_a + Q_R)(c) / 10^6$

Where,

H_{WLA} = Waste Load Allocation Heat Load (MW)
HUA = Human Use allowance (ºC)
Q_a = Point Source Effluent Flow (Cubic Meter/Second)
Q_R = Upstream River Flow (Cubic Meter/Second)
c = Specific Heat of Water = 1.0 cal/g*ºC = 4.1868×10^6 J/(m^3xºC)
10^6 = conversion factor from Joules/Second to Megawatts

(J = joule, cal = calorie, m = meter, g = gram, MW = megawatt)

During the time of greatest thermal stress, late July and early August, the wasteload allocation, as a daily maximum, would typically be as follows (under a natural stream flow of 3 cubic feet per second and facility dry weather design flow of 0.25 million gallons per day – actual direct discharge would be less due to land application diversion of part of the facility effluent):

$$H_{WLA} = [0.2\ ºC * (0.011\ CMS + 0.85\ CMS) * 4.187\ E6\ J/(m^3 xºC)] / 10^6 = 0.085\ MW$$

where CMS = cubic meters per second

Effluent temperatures are limited by the WLA and further limited by the application of **Equation 4.5-3** (**Section 4.5**, **Appendix D**). **Equation 4.5-3** defines the allowable effluent temperature, based on mixing and targeting the applicable criteria plus the HUA.

The WLA applies only to the direct discharge. Any seepage from land application would be expected to have a cooling influence, below the applicable temperature criteria.

Oregon Co-Gen, LLC Power Generating Facility. The Oregon Co-Gen facility is permitted to discharge year round, in two modes. Effluent is either piped directly to Willow Creek or into a rapid infiltration basin adjacent to the Creek. The facilities peak effluent discharge can range from 0.122 million gallons per day (0.189 cubic feet per second) to 1.69 million gallons per day (2.62 cubic feet per second).

As with the Heppner WWTP, the wasteload allocation for the Oregon Co-Gen facility is expressed as a Willow Creek daily maximum heating rate, issued as an equation (**Equation 4.5-2**, **Section 4.5**, **Appendix D – excerpt previous in this section**). The heating rate is expressed in megawatts, and is dependant upon the HUA, effluent discharge and river flow. The HUA for the facility is the same as for the Heppner WWTP, 0.2 ºC (0.36 ºF), as discussed in **Section 1.3b**. The facility is currently not operating, and there is little track record with which to evaluate the most likely effluent discharge rates. Even at the higher end of discharge, facility heat load will not result in exceedance of the water quality standard outside of the mixing zone, due to the application of effluent temperature limits from **Equation 4.5-3**.

During the time of greatest thermal stress, late July and early August, the wasteload allocation, as a daily maximum, is roughly estimated as follows (under a natural stream flow of 3 cubic feet per second and facility output of 1.69 million gallons per day):

$$H_{WLA} = [0.2\ ºC * (0.074\ CMS + 0.85\ CMS) * 4.187\ E6\ J/(m^3 x ºC)] / 10^6 = 0.133\ MW$$

Abbreviations are defined previously in this section.

Effluent temperatures are limited by the WLA and further limited by the application of **Equation 4.5-3** (**Section 4.5**, **Appendix D**). **Equation 4.5-3** defines the allowable effluent temperature, based on mixing and targeting the applicable criteria plus the HUA.

The WLA applies to the direct discharge and to the rapid infiltration basin, as described in **Section 4.5**, **Appendix D**.

(1.3h) Load Allocations, Surrogates and Measures of Progress

Load allocation is defined as "The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources or to natural background sources" (40 CFR 130.2(g)). "Sources" means *sources of pollutants*, in this case excess heat.

The load allocation for the simulated stream corridor is the natural potential warm season solar heating, summarized graphically in **Figure 1.3-4**, as a daily longitudinal heating rate per stream surface area (heat flux in W/m^2). Effective shade is proportional to heat flux and is shown in the figure as well and discussed subsequently in this section as a surrogate measure. Heat fluxes are assessed at 100 meter (328 feet) intervals along the mainstem. In total, this load allocation is a maximum daily heating rate of 139 megawatts, representing 43 percent of the existing heat loading for the simulated corridor (**Section 1.3d**). This loading is attributed to natural background sources. The load allocation is a measure of the reduced heating associated with taller and denser vegetation and a narrower channel, relative to existing conditions, as discussed in previous sections. **Chapters 3** and **4** of **Appendix D** describe NTP conditions and the simulation of associated heat transfer in greater detail.

Figure 1.3-4. {Modified from **Appendix D**, **Figure D4-2**} *Load allocations for the simulated length of Willow Creek, expressed here as one-kilometer moving averages. The load allocation is channel and vegetation NTP heat flux within the range of potential vegetation heights shown in yellow. The red line illustrates the existing condition. For location reference - river miles, key locations and tributaries are related to river kilometers in* ***Figure 1.2-3****.*

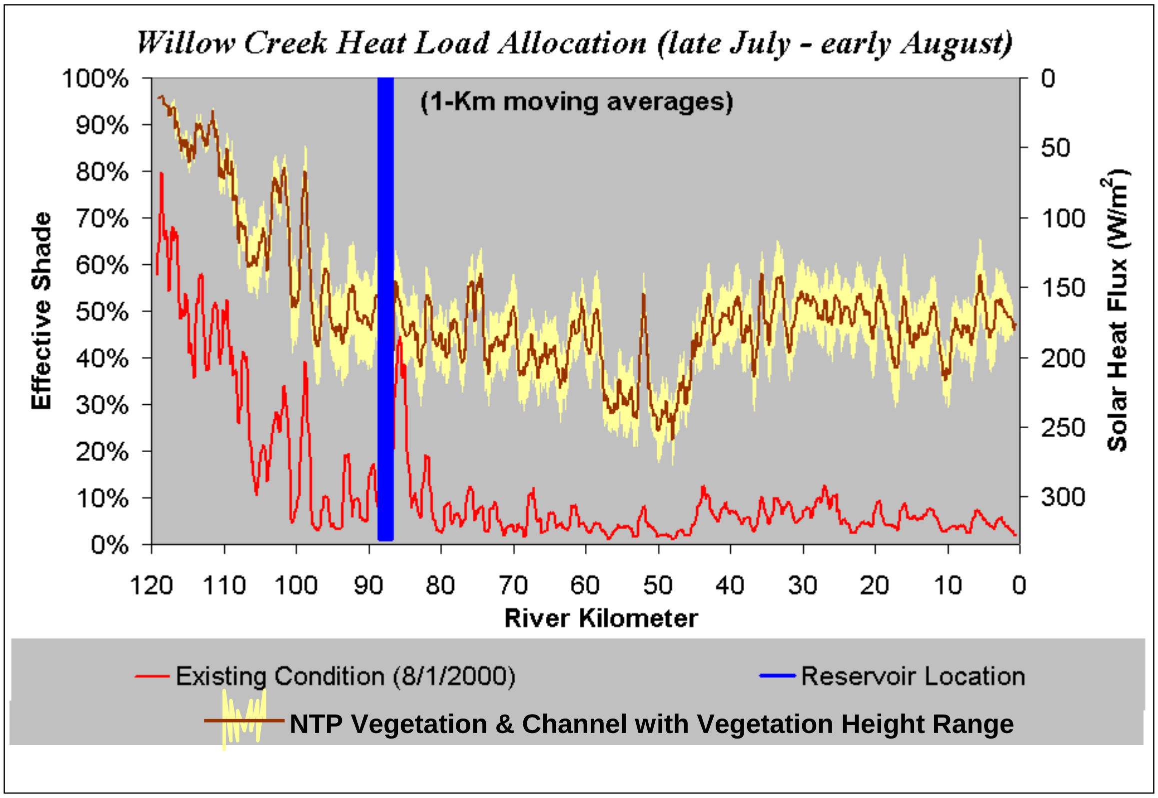


Figure note: The vegetation NTP range about a midpoint is simulated via three model runs producing temperature output for: (1) max estimated height, and (2) 87.5 % (midpoint) of the maximum height estimate and (3) 75 % (low estimate) of the maximum height estimate. This range accounts for uncertainty in estimating natural vegetation structure. In ***Figure 1.3-4****, this range is plotted around the combined vegetation and channel NTP instead of the vegetation-alone mid-range height scenario shown in* ***Figure D4-2*** *of* ***Appendix D****. For explanation of the vegetation height ranges, refer to* ***Appendix D****,* ***Section 3.3.3****.*

Because the aim of the applicable criteria of the temperature standard is NTP, human activities do not receive an allocation. DEQ recognizes that attaining NTP conditions may be a lengthy process and that cost and other limitations may be encountered. This should be addressed in the TMDL implementation plans prepared by designated management agencies. DEQ also recognizes that at various times and locations attainment of NTP conditions may be impeded by natural disturbance.

Surrogate Measures

As used here, a load allocation *surrogate measure* is an alternative expression of a TMDL. Where feasible, TMDL allocations are expressed as a maximum amount of pollutant per time. This enables an 'apples to apples' division of loading among point and nonpoint sources, natural and human sources, existing and future sources. However, radiant heat energy per time, employed when addressing solar radiation, is not readily translatable to on-the-ground management. Therefore surrogates, such as *effective shade,* are established to translate the TMDL to everyday terms. Attainment of the effective shade surrogates below fulfills the Willow Creek Subbasin load allocation. The effective shade surrogates address both shade-producing features and stream width, thus entirely addressing solar radiation received by streams. Resource managers can measure effective shade at any point on a stream with an instrument such as a Solar Pathfinder™.

For purposes of this TMDL, effective shade is defined as the percent reduction of potential solar radiation load delivered to the water surface, over the course of a mid-summer day**. Figures A1-5** and **A1-6** of **Appendix D** illustrate this definition. Effective shade translates linearly to the solar radiation heat load allocation (**Figure 1.3-4**).

SURROGATE MEASURE #1 – Site Specific Effective Shade for Willow Creek.

Surrogate Measure #1 is the NTP site effective shade shown in **Figure 1.3-4** (channel and vegetation potential). This surrogate, as a site-specific measure, is developed only where temperature simulation was conducted – on the mainstem of Willow Creek. The vegetation and channel potential incorporated into this surrogate are described in **Appendix D**, **Chapter 3.0**.

SURROGATE MEASURE #2 – Effective Shade Curves for perennial streams other than the simulated part of Willow Creek.

This surrogate applies on perennial, or potentially perennial, tributaries where temperature and shade were not simulated. This surrogate is expressed as effective shade curves in **Figure 1.3-5**. The curves are based on the relationship of NTP vegetation to channel width. NTP vegetation is described and mapped in **Appendix D**, **Chapter 3.0**.

Effective shade curves are designed to display effective shade levels for a specific land cover type as a function of channel width. The curves presented in this document are developed for the Willow Creek Subbasin (i.e., vegetation assessment, latitude and longitude) and are accurate for the critical time period (**Section 1.3j**). The method considers stream aspect (flow direction) as well. Estimated natural potential vegetation height and density are identified on the shade curve graphs of **Figure 1.3-5**.

In order to apply these curves, a resource manager will (1) choose a stream location, (2) measure the existing channel width (3) select the appropriate curve based on the channel compass direction. The effective shade indicated by the curve for that channel width is the expected shade if NTP vegetation height and density is in place. Simply put, perennial tributaries should target the NTP vegetation range.

Figure 1.3-5. *Recall of Figure 4-6a through 4-6c, Appendix D (next 3 pages). Captions are color coded corresponding to **Figure 1.3-6** where geographic application is identified.*

{Appendix D, Figure D4-6a. *Effective Shade Curves for natural potential riparian vegetation where conifers are expected to predominate}*

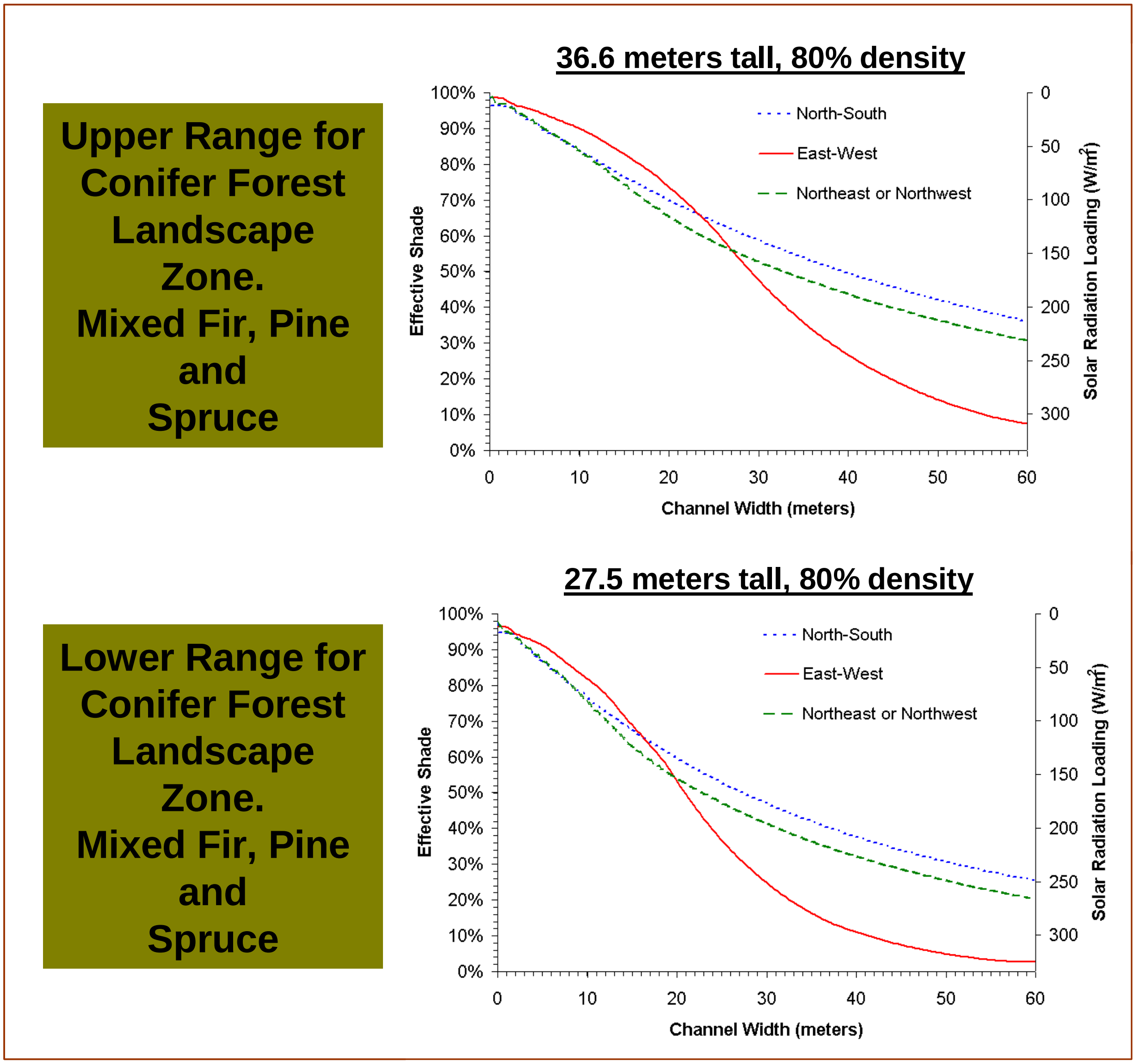
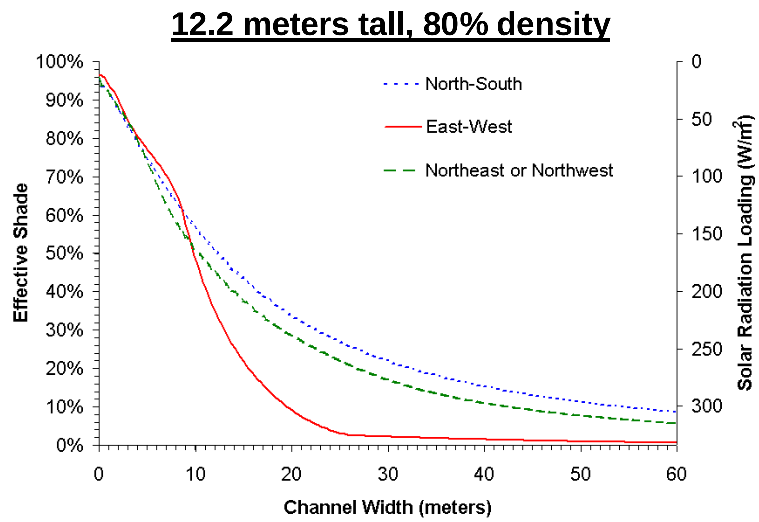


Figure 1.3-5 Continued…

{Appendix D, Figure D4-6b. *Effective Shade Curves for natural potential riparian vegetation where deciduous trees are expected to predominate*}

Upper Range for Shrub/Agriculture Landscape Zone. Mixed Willow, alder, Cottonwood, meadows and other



Lower Range for Shrub/Agriculture Landscape Zone. Mixed Willow, alder, Cottonwood, meadows and other

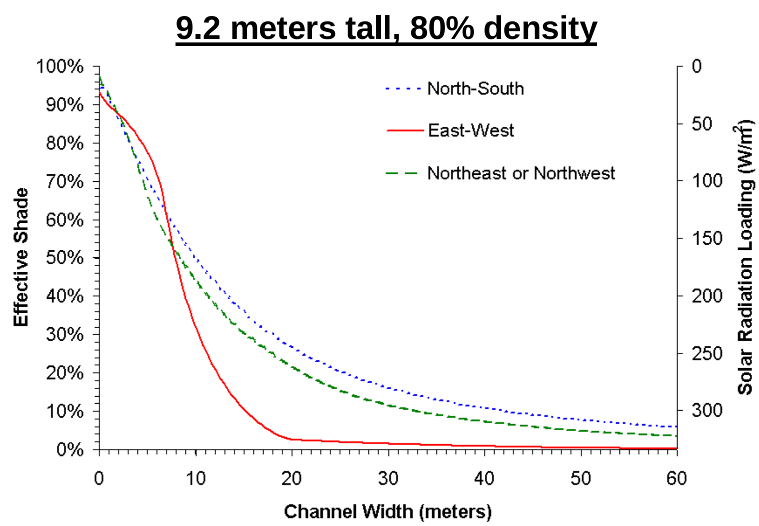
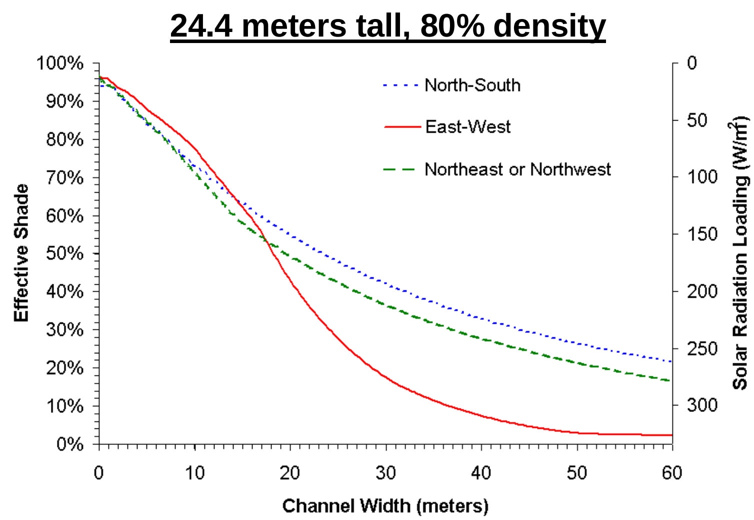


Figure 1.3-5 Continued…

{Appendix D, Figure D4-6c. Effective Shade Curves for natural potential riparian vegetation where mixed conifer and deciduous stands are expected to predominate. These curves are not pre-specified zonally, as this level of detail was not assessed at the scale of this analysis – Instead they should be applied where best professional judgment, soils, climate and existing stands guide identification of natural vegetation.}

Upper Range for Areas of mixed Conifer & Deciduous (Location not specified)



Lower Range for Areas of mixed Conifer & Deciduous (Location not specified)

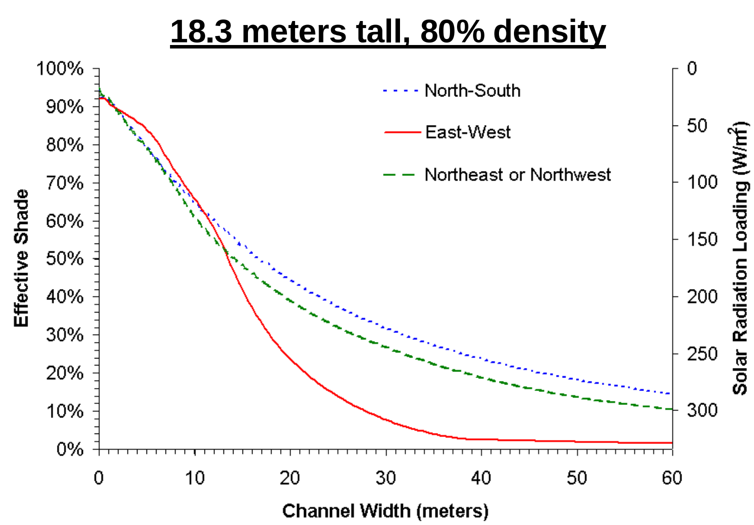


Figure 1.3-6. *{Recall of Figure D4-5, Appendix D} Geographic application of shade curves*

SURROGATE MEASURE #3 – Channel Width, Stream Type and Width/Depth ratios.

Surrogate Measure # 3 addresses the estimated NTP channel width, type and width/depth ratios shown in **Figure 1.3-7** and **Table 1.3-4**. Though this is accounted for in the site-specific effective shade determination of **Figure 1.3-4**, channel width in itself provides a direct and simple measure of stream condition related to heating processes. The channel width and stream type surrogate applies to the simulated river corridor. The derivation of NTP channel widths is described in **Chapters 2** and **3** of **Appendix D.** Channel complexity is a related factor that typically provides thermal and ecological benefits. Features such as beaver ponds and braided meadow areas may widen streams and yet provide a cooler (increased hyporheic exchange), more natural setting. Channel complexity, where resultant from decreased human stress to the channel and riparian area, can be substituted for the channel width surrogate target.

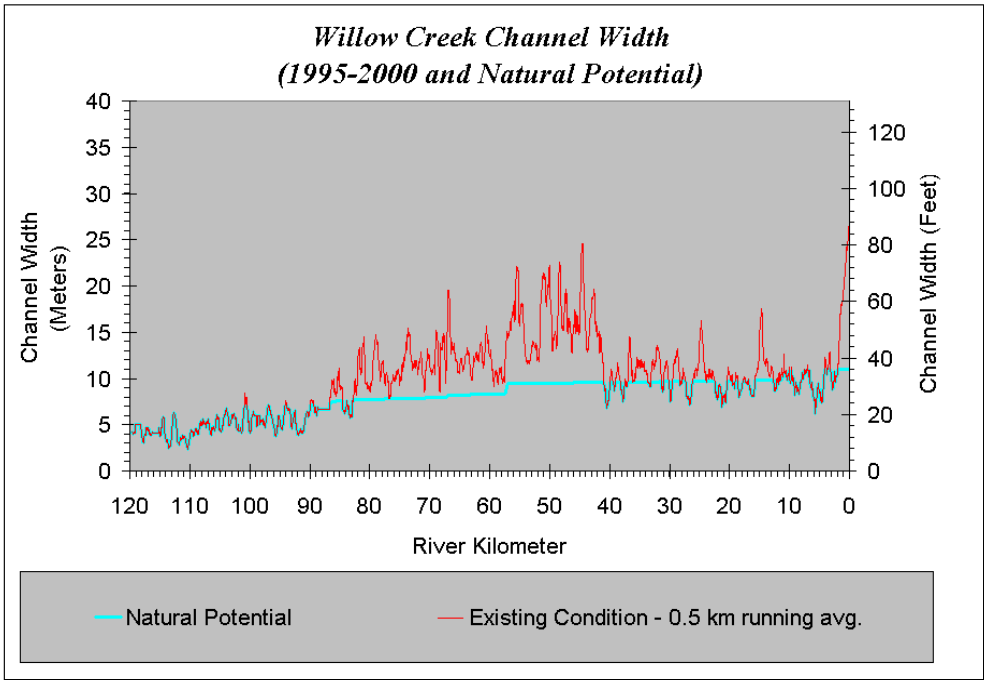


Figure 1.3-7. *{Recall of Figure D3-11, Appendix D} Existing and NTP channel width for Willow Creek*

Table 1.3-4 displays the width/depth ratios used in the Willow Creek temperature simulations to represent NTP. The rationale and relation to local measurements is described in **Appendix D**. The ratios are applied using the Rosgen (1996) classification stream type. For Willow Creek, C-type predominates as the existing stream type. Much of the remaining Willow Creek channel is expected to evolve toward a C-type configuration as well. The width/depth goals should be applied within and outside of the modeled corridor, throughout the perennial stream network. The Rosgen stream classification is described in **Chapter 2** of **Appendix D**. Stable natural channel types for perennial tributaries have not been determined, though it is expected that types C, B and A would predominate, generally in order of increasing elevation for any given stream.

Table 1.3-4. *{Recall of Table D3-1, Appendix D} Width-Depth ratio targets. Values are median width/depth from streams in several states in the US (Rosgen, 1996)*

Measured width/depth ratios (mid-range of the greatest mode)				
Stream Type	A	B	C	F
width/depth	7	17	24	29

Willow Creek Reservoir Load Allocation

Willow Creek Reservoir is issued a TMDL, herein referred to as a load allocation. The allocation is considered applicable regardless of the ultimate legal definition of reservoirs as point or nonpoint sources of potential pollution, and could serve as either a load or wasteload allocation. The allocation issued here is twofold. First, a near field heat load limit established via the equation, in the excerpt below, along with the temperature target. The LA and temperature limit are as described in **Method of Allocation**, **Appendix D** (**Section 4.5**), and recalled here:

Near Field LA: Excerpt from Section 4.5, Appendix D

Willow Creek Reservoir

Load Allocation: The Reservoir does not add effluent to the creek in the manner that a piped point source does. The added heat load from the Reservoir is the amount of heat energy needed to increase the volume of water released from the dam by 0.2 ºC, on a rate basis. This is calculated with a form of **Equation 4.5-2**, as follows:

Eq. 4.5-4: $H_{LA} = (HUA * Q_R * c)/10^6$

Where,

H_{LA} = Load Allocation Thermal Load (MW)

Q_R = Reservoir outlet flow (variable, cubic meter/second)

c = specific heat of water = 4.1868×10^6 J/(m^3xºC)

HUA = Human Use Allowance (**0.2 ºC**)

10^6 = conversion factor from Joules/Second to Megawatts

Temperature Target: As discussed previously in this section, the applicable criteria for the Reservoir outlet is 20.0 ºC during the critical period (**Chapter 5.0**). Adding the HUA as discussed previously in this Section, the target for the Reservoir outlet is 20.2 ºC.

(J = joule, m = meter, g = gram, MW = megawatt)

During the time of greatest thermal stress, late July and early August, the load allocation would typically be as follows (daily maximum under a natural stream flow of 3 cubic feet per second):

$$H_{LA} = [0.2\ ºC * .085\ CMS * 4.187\ E6\ J/(m^3 xºC)] / 10^6 = 0.071\ MW$$

where CMS = cubic meters per second

Second, a narrative load allocation is established to account for downstream temperature influence, up to several miles from the dam: ***The Willow Creek Reservoir discharge is restricted to the allotted 0.2 ºC of the human use allowance for Willow Creek, as far downstream as the Reservoir influences stream temperature***. The reason for this narrative far-field allocation is that Reservoir releases normally exhibit a smaller diel temperature range than the stream. Daily minimum outlet temperatures are often greater than NTP stream minima during the critical period. Accordingly, significant temperature impacts may occur a half-day or so downstream, as water released in early morning hours, already relatively warm, has less of a climb to temperatures potentially in excess of NTP. The Clackamas River provides an example, where temperature simulation in relation to a reservoir yielded temperatures several degrees in excess of NTP ten miles below the dam (Willamette TMDL, DEQ, in preparation).

Implementation Responsibilities

Designated Management Agencies are responsible for developing and implementing plans to fulfill TMDL load allocations and surrogate measures. These agencies are identified in **Part 2**, the TMDL Water Quality Management Plan. The agency Implementation Plans typically stem from their existing programs, and once submitted, are included physically or by reference in the WQMP. These Implementation Plans must meet the requirements of OAR 340-042.

The process for identifying DMAs is straightforward. DEQ identifies existing jurisdictional responsibility for water quality in the areas where the load allocations apply. For example, the Oregon Department of Agriculture is the DMA for areas near the stream in which agriculture and rural residential land use are predominant. **Figure 1.2-3** indicates land use by location along Willow Creek. **Section 1.3f** further discusses DMA identification.

Through management planning, projects and ongoing assessment, the DMAs are expected to ensure that all feasible steps are taken toward attainment of the load allocations and surrogate measures of this section. Other measures of progress are provided as well, in the next sub-section.

Measures of Progress

In addition to the previously described load allocations and surrogates, other targets can be tracked as progress is made towards a more natural heating condition. With some exceptions, these other targets, or 'measures of progress' have not been evaluated in terms of temperature reduction due to limitations in assessment or model capabilities. However, some measures can be quantified in terms of their expected values in the Willow Creek Subbasin (e.g., sinuosity), and some can be addressed narratively.

These measures of progress are listed in **Table 1.3-5**. These do not have the status of a TMDL load allocation or TMDL surrogate, because "surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve" (EPA 1998). While these measures clearly lead to more natural and generally cooler streams, quantitative assessment of their cooling is impractical. These measures are included here to increase clarity on the range of management practices and projects available to bring the stream system to a more natural thermal condition.

Table 1.3-5. *Measures of progress*

Measure	Suggested Objective
Sinuosity	General increase
Bank stability	General increase
Bed/channel stability	Relative Bed Stability Index (Kaufmann, 1999)
Upland and bank erosion	General reduction where increased by human activities
Increased channel complexity (increased pool frequency & large woody debris where appropriate; increased space for overflow/side channels, oxbows, off-channel pools, sloughs and other wetlands; and other enhancements to hyporheic exchange). *This measure can substitute for channel width surrogate allocation.*	Support natural channel evolution with decreased bank and riparian disturbance.
Increased active floodplain area	Setback levees, increased space, vertical channel stability
Diel temperature range	**Figure 1.3-8**
Increased flow	Discussed in **Chapter 3** of **Appendix D**
Vegetative buffer width	Sufficient to allow for maximum vegetation density and resilience

Figure 1.3-8 displays the calculated NTP diel (24-hour change) temperature range. The reader is referred to **Appendix D** for details. The diel temperature range is a measure of progress as identified in **Table 1.3-5**. It serves as an indicator of change in solar heat input. More importantly, decreased temperature cycling is generally beneficial to aquatic life, particularly when daily maximums decrease as well.

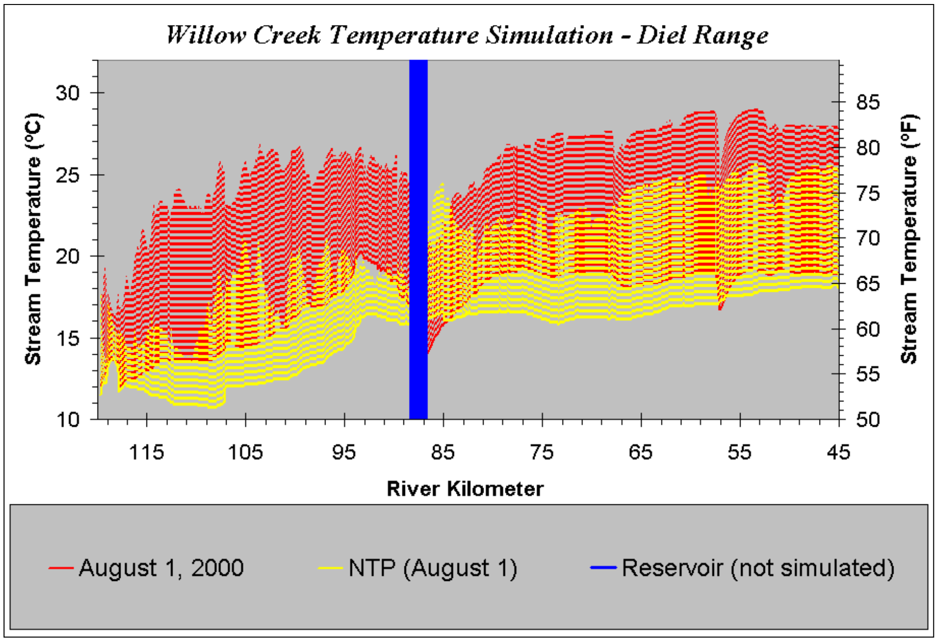


Figure 1.3-8. {**Recall of Figure D4-13**, **Appendix D**} *August 1 longitudinal profile of simulated 2000 and NTP diel temperature pattern (NTP addresses vegetation, channel and flow)*

(1.3i) Margin of Safety

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the effect controls will have on loading reductions and receiving water quality. A MOS is expressed as unallocated loading capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The MOS for the Willow Creek Subbasin Temperature TMDL is implicit, based on conservative analytical assumptions and numeric targets:

- Conservatively low estimates for groundwater inflow were used in stream temperature calibrations. Recall that groundwater directly cools stream temperatures via mass transfer/mixing.
- Cooler microclimates associated with mature natural near stream land cover were not accounted for in the simulation methodology.
- Point source and Reservoir temperature limits target the lower range of estimated NTP.
- Heat reduction objectives are maximized through targeting natural conditions and adaptively re-assessing natural condition targets through an iterative TMDL process.

(1.3j) Seasonal Variation and TMDL Time Frame

This TMDL addresses warm season exceedances of temperature standard criteria. The 2004/2006 303(d) lists references the listing as “year around,” because the 20 ºC (68 ºF) biologically-based numeric criteria [§ 041-0028 (4)] in the pre-TMDL context applies throughout the year. However, as shown in **Appendix D**, **Figure D5-1** (recalled below) there is no indication of exceedance outside of June through September. Maximum temperatures and solar heat loading, and lowest stream flow all typically occur in late July and early August. Such worst-case conditions are normally referred to as “*critical conditions*.” Accordingly, the interval covered by TMDL temperature modeling, July 21 through August 9, addresses critical conditions.

Point source permits require careful consideration of seasonality. The seasonal time-frame of the TMDL applicability, however, is not a critical concern for nonpoint sources. This is because channel and vegetation restoration are required to reduce summer heating. These improvements are perennial and do not lend themselves to seasonal manipulation.

The term *critical period* is defined for the purpose of this document as the time frame within which the TMDL applies, and in particular to the NPDES sources and Reservoir wasteload and load allocations. The TMDL addresses exceedance of water quality standards. Hence the critical period is the time when the standard is exceeded. This could become somewhat complicated, because the TMDL assessment provides for a newly applicable standard – the natural conditions criteria – which is only applicable during the time for which it is assessed. However, as the natural conditions criteria and the biologically-based criterion for Willow Creek have the same value at the NDPES sources and Reservoir, the critical period of concern is the time frame during which Willow Creek exceeds 20 ºC in the Heppner vicinity.

The critical period for NPDES sources and the Willow Creek Reservoir is further discussed in **Appendix D**, and included as an excerpt below. For discussion of the 20 ºC natural condition criterion mentioned therein, refer to **Section 1.3b** of the main document. The following excerpt also illustrates the existing seasonal variation of temperature at various locations in the Subbasin, based on available data from multiple organizations.

Excerpt from Section 4.5, Appendix D

Current seasonal patterns are portrayed and compared to Oregon water quality standard biologically-based criteria in **Figure D5-1**. Several years and locations are shown, as data were available. The 20 ºC biological criterion for redband trout applies throughout the Subbasin except when exceeded by the natural condition criteria (which for Willow Creek happen to be the same, for the specified point sources and Reservoir), or superseded by other criteria or restrictions such as the anti-degradation policy of the temperature standard. The peak 7-day averaged daily maximum natural condition criteria displayed in **Figure D4-12** effectively sets annual maxima criteria at varying levels along Willow Creek.

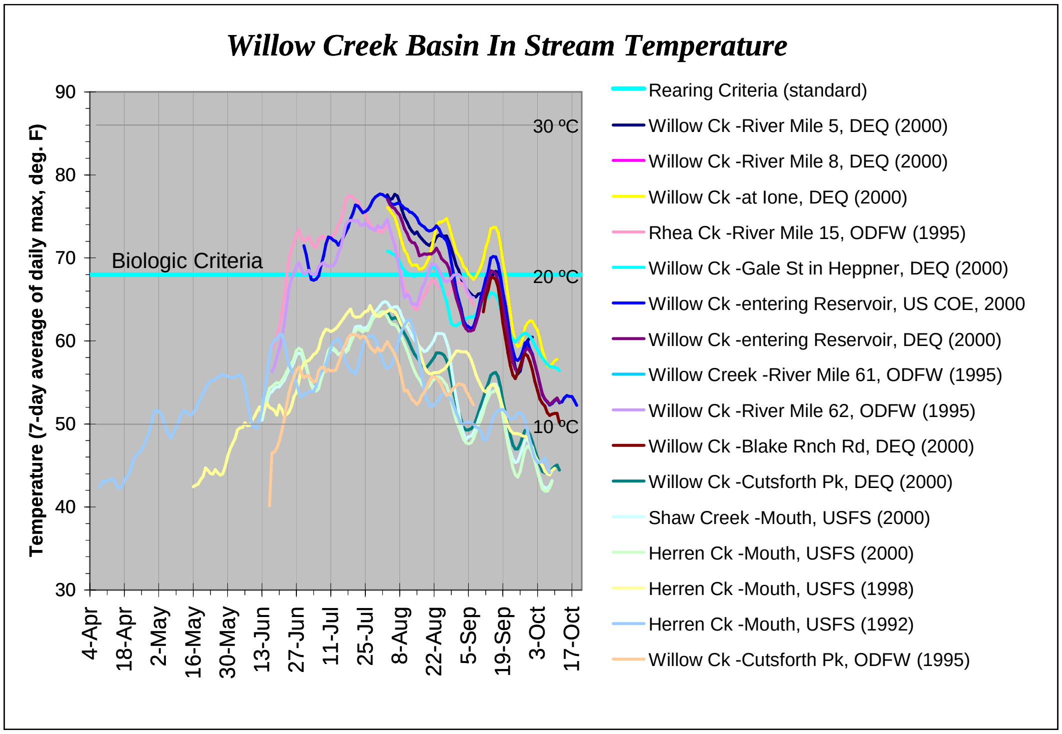


Figure D5-1. *Willow Creek and tributary seasonal pattern seven-day average daily maximum temperature for various years and locations. The applicable biologically-based criterion of the water quality standard is displayed as well.*

Critical Period. For the Reservoir and the two facilities receiving waste load allocations, the critical period (the time frame that this TMDL applies to these sources) is the time during which Willow Creek exceeds 20 ºC – the natural conditions criterion for these sources. This exceedance typically occurs within late June to late September in the Heppner vicinity. During the critical period, the applicable criterion is 20 ºC for these sources. Outside of this time frame, the temperature TMDL does not apply to the Reservoir and NPDES sources.

(1.3k) Reserve Capacity

No reserve capacity is assigned. This is because the Department has not received application for new NPDES permits in the Willow Creek Subbasin, or other indications of need for new or increased stream heat sources. This could change in subsequent iterations of the Willow Creek Subbasin TDML.

Water Quality Standard Attainment Analysis

The temperature TMDL is achieved during the warm season when (1) nonpoint source solar radiation heat loading is at a natural level and (2) point source and Reservoir discharges cause no measurable temperature increases in surface waters or are within the allotted temperature targets and human use allowance. With regard to the NPDES individual-facility permits, the latter appears readily achievable. For the City of Heppner discharge, in August 2005, temperature measurements between 3:00 and 4:00 p.m. (n=11) ranged from 20.6 - 22.2 ºC (69 - 72 ºF). At a river flow of 3.0 CFS (0.08 CMS) and effluent discharge of 0.25 CFS (0.007 CMS), **Equation 4.5-3** (**Appendix D**, **Section 4.5**) yields allowable effluent temperatures up to 22.6 ºC (72.7 ºF). Accordingly, the facility has been in advance compliance. Concerning the Oregon Co-Gen facility, projected in-stream temperatures after mixing (**Table 1.2-7**, **Section 1.2**) are less than 20 ºC (68 ºF). Effluent temperature limits from this TMDL will be incorporated into facility permits upon their next scheduled renewal.

With regard to the Willow Creek Reservoir, in 2005 (the most recent warm season data prior to preparation of this document) the target is being exceeded by approximately 2 ºC (3.6 ºF) during the warmest days of summer (**Figure 1.3-9**). Reduced mixing via aeration or reduced selective withdrawal elevation would lead to lower temperatures, however this could lead to pH criteria exceedance in Reservoir outlet flow. The Department expects that strategic timing and operations will provide for a balance of conditions leading to the attainment of standards for both parameters, and that this will be indicated in the TMDL Implementation Plan for the Reservoir.

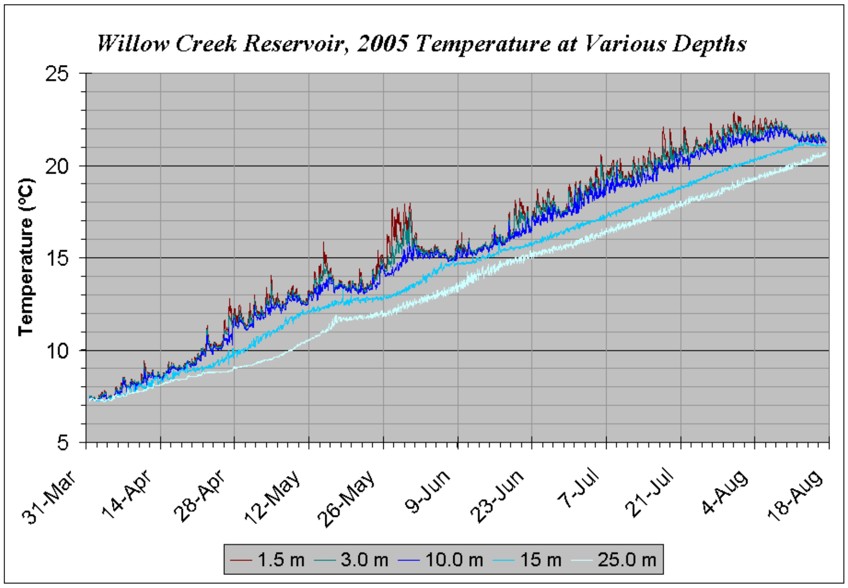


Figure 1.3-9. *Willow Creek Reservoir temperature at various depths, 2005, data from US Army Corps of Engineers*

Nonpoint source attainment can be evaluated through the TMDL temperature simulations. The peak 7-day average of the daily maximum is calculated for July/August 2000 and NTP simulations of Willow Creek through most of its length. Attainment of NTP channel and riparian conditions would enable a summer afternoon spatial median temperature reduction of 7.0 ºC (12.6 ºF) above the Reservoir and 2.8 ºC (5.0 ºF) below the Reservoir (**Section 4.4**, **Appendix D**).

The time span for attainment of the natural condition criteria during the critical period in Willow Creek relies much on reduction in nonpoint source heat input. Modeling indicates that vegetation is the single most dramatic source of heat reduction, by far. Once passive or active restoration is underway and larger vegetation begins to establish, substantial improvement could take place in one to three decades. However, at this point insufficient information is available to account for the time required to fully adopt management practices leading to TMDL and standards attainment.

1.4 TMDL FOR PH

Introduction

The Department is addressing pH for Willow Creek primarily through a pH target rather than an allocation of pollutant loading. The technical basis for this approach is described in **Appendix E** along with data evaluation and summary. The Willow Creek subbasin, point sources and 303(d) listings are described in **Section 1.2**. **Table 1.4-1** summarizes the pH TMDL.

Table 1.4-1. *pH TMDL Summary*

Water body	Willow Creek Subbasin, Hydrologic Unit Code #17070104. Water body is Willow Creek from Willow Creek Reservoir to mouth.
Water Quality Standard	OAR 340-041-0021 & OAR 340-041-0315 (pH)
Applicable Water Quality Standard Criteria	Within pH of 6.5-9.0 standard units
Target Pollutant / Loading Capacity	At Heppner: the Willow Creek pH TMDL utilizes a pH target as "other appropriate measure" (40 CFR 130.2(i)) Below Heppner: temperature TMDL target and loading capacity and precautionary restriction of dissolved inorganic nitrogen from two point sources to existing loading.
TMDL Surrogate	Reservoir outlet pH, temperature TMDL surrogates
Existing Pollutant Sources	Sun light, solar heat and nutrients in and below Willow Creek Reservoir
Margin of Safety	<u>Implicit</u> At Heppner: TMDL currently attained (ongoing maintenance needed) Below Heppner: the temperature TMDL targets natural flow and solar input
Reserve Capacity	Not identified. Any new discharges should be maintained within 6.5-9.0 standard units.

(1.4a) Name, Location and 303(d) Listings

Section 1.2. includes further discussion. In brief, the water body is Willow Creek below the Willow Creek Reservoir and the listing is based on data collected in the 1980's in the vicinity of the city of Heppner. Additional data was collected during 2000 and 2001 during TMDL monitoring. The additional monitoring indicated an exceedance of the pH standard near Lexington.

(1.4b) Pollutant and Target Identification

The cause of elevated pH in Willow Creek is excess algae associated with (1) unnaturally increased heat, light and/or nutrient input or accumulation associated with the Willow Creek Reservoir and (2) excess heat and light associated with low instream flow, channel conditions and lack of stream shading downstream from the City of Heppner. Supporting data and the relationship between pH and algae are discussed in **Appendix E**. The pollutant parameters are solar heat, light and nutrients.

Pollutant target levels specific to pH are not identified because (1) at Heppner elevated pH is associated with the Willow Creek Reservoir, and can be controlled by operational modifications and (2) below Heppner temperature TMDL implementation will address pH, as explained in **Appendix E**. This TMDL establishes a TMDL surrogate target of 6.5-9.0 pH for the Willow Creek Reservoir outflow (all pH measurements associated with this document are in standard units). Excess daily pH fluctuations near Lexington and downstream appear slight (based on minimal data) and should be moderated through temperature TMDL implementation, which establishes targets for natural channel morphology and vegetation.

(1.4c) Water Quality Standards and Beneficial Uses

The primary benefit of achieving the pH standard is to provide conditions that support a healthy distribution of aquatic life including salmon and trout.

Oregon Administrative Rules specify the beneficial uses to be protected in the Willow Creek Subbasin. OAR 340-041-0320 provides that water quality in the Subbasin will be managed to protect the beneficial uses shown in **Table 1.2-1**, **recalled below**. The uses which can be adversely influenced by excess pH are highlighted in this table.

Recall Table 1.2-1. *Designated Beneficial Uses, Umatilla Basin, including Willow Creek Subbasin (OAR 340-41-0310, Table 310A). The use most sensitive to widely fluctuating pH is highlighted.*

Beneficial Uses	Umatilla Subbasin	Willow Creek Subbasin
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X (at mouth)
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	X
Commercial Navigation & Transportation		

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.
[2] See also Figures 310A and 310B for fish use designations for this basin.
Table produced November, 2003

OAR 340-041 further specifies fish uses to be protected in the Willow Creek Subbasin as shown in **Figures 310A** of the rule. **Figure 310A** is a map of the waters of the encompassing Umatilla Basin with designations as to their use by salmonids. The map is available on DEQ's web site at http://www.deq.state.or.us/wq/standards/FishUseMapsFinal. The map shows that all waters of the Willow Creek Subbasin are designated for "Redband or Lahontan Cutthroat Trout." Redband trout are present in Willow Creek Subbasin. For pH, salmon and trout viability is the most sensitive beneficial use.

Oregon Administrative Rules provide as follows, with provisions applicable to the Willow Creek Subbasin underlined:

Oregon Administrative Rule 340-041-0021 (pH)

(1) Unless otherwise specified in OAR 340-041-0101 through 340-041-0350, pH values (Hydrogen ion concentrations) may not fall outside the following ranges:

(a) Marine waters: 7.0-8.5;
(b) Estuarine and fresh waters: 6.5-8.5.

(2) Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria are not in violation of the standard, if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria.

340-041-0315 (Umatilla Basin)

Water Quality Standards and Policies for this Basin

pH (hydrogen ion concentration). pH values may not fall outside the following range: all Basin streams (other than main stem Columbia River): 6.5-9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department will determine whether the values higher than 8.7 are anthropogenic or natural in origin.

The pH target for this TMDL is the water quality standard upper limit of 9.0. The Departmental determination of whether values higher than 8.7 are anthropogenic was not formalized. This is because twenty-five percent of ambient measurements taken between June and September, up to date, do not exceed 8.7 (**Appendix E**).

(1.4d) Loading Capacity

As described in **Section 1.4b**, a target pollutant level is not established in this TMDL. Accordingly, a loading capacity is not established via this pH TMDL. This is because the solution to afternoon pH reduction near Heppner lies in Reservoir management alternatives rather than a more conventional form of pollution reduction. In the Lexington vicinity, slightly elevated pH was measured during TMDL monitoring in 2001. However, insufficient flow precluded predictive analysis of Willow Creek in this reach. Fortunately, the temperature TMDL allocations and natural flow objective provide basis for pH moderation in lower Willow Creek.

(1.4e) Excess Load

Excess load is not calculated for this pH TMDL. Refer to **Section 1.4d** and the temperature TMDL (**Section 1.3**).

(1.4f) Pollutant Sources and Jurisdictions

Pollutant sources are described in **Section 1.4b** and further discussed in **Appendix E**. Jurisdictions are as follows:

- Willow Creek Reservoir pH target: US Army Corps of Engineers
- Temperature load allocations: refer to **Section 1.3** TMDL for temperature
- Individual-facility NPDES permit sources: City of Heppner and Oregon Co-Gen, LLC (note that these discharges are not a source of pH standard exceedance in Willow Creek at Heppner)

As discussed in **Appendix E**, elevated summer afternoon pH is attributed to algal activity in Willow Creek Reservoir and potentially in Willow Creek below the Reservoir.

(1.4g) Wasteload Allocations (point sources)

Wasteload allocations are, as a precaution, set at current daily loading for dissolved inorganic nitrogen. These WLAs apply to both individual-facility NPDES discharges. The existing permit limits for effluent pH (6.5-9.0) should be maintained. Analysis and rationale are provided in **Appendix E**. In particular, the rational for not requiring reduced nutrient levels for these point sources is based on (1) the pH exceedance measured at Lexington is slight, (2) elevated pH in relatively stagnant systems may be natural as flow attenuates to near zero, (3) substantial distance intervenes between Lexington and the Heppner area point sources – 15 kilometers (9 miles), and (4) increased flow in recent years may have already addressed the issue. The selected alternative is long-term monitoring associated with temperature TMDL implementation. This rationale is discussed in greater detail in **Appendix E** in the Section entitled **Below the USGS Gage Site.**

Currently there are insufficient nutrient data available to characterize current loading and no limits are specified in the permits. Regarding the two individual-facility NPDES permits, the Department and/or permittees will statistically characterize the dissolved inorganic nitrogen concentration trends when sufficient samples are available and take action as needed if a significant increase is indicated.

(1.4h) Load Allocations and Surrogates

“TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure” (40 CFR 130.2(i)). For pH in Willow Creek, the Department invokes surrogate (other appropriate measure) measures and the temperature TMDL to address pH, with regard to nonpoint sources:

- The Willow Creek Reservoir outflow shall be maintained within 6.5-9.0 standard pH units, on any given day during the applicable time frame.
- Implementation of temperature load allocations and surrogates.

Other measures are encouraged in support of pH moderation: as feasible, natural flow levels should be established in Willow Creek during July through September; and nutrient output loading from Willow Creek Reservoir should be minimized.

(1.4i) Margin of Safety

The establishment and implementation of the temperature TMDL provides an implicit margin of safety below Heppner, in that it targets natural thermal conditions. These conditions will lead to more natural pH levels as well. The natural condition targets of the temperature TMDL represent a substantial change from current conditions, whereas the pH exceedance measured at Lexington is slight, and may have already been addressed through increased summer Reservoir outflow since 2003. The reduction in solar heating and increased flow associated with the temperature TMDL is likely to provide for the slight reduction in pH needed to meet water quality standard criteria. Temperature TMDL modeling predicts that natural early August afternoon temperatures for Willow Creek at Lexington would be 18-20 ºC (64.4-68.0 ºF), a substantial decrease from the existing 26-28 ºC (78.8-82.4 ºF). The natural temperature in Lexington would be very similar to existing temperatures in lower Heppner (18.8-19.6 ºC (65.8-67.3 ºF)), where summer afternoon median pH is currently less than 8.0 and no pH standard exceedances have been measured.

The MOS is further addressed at the Reservoir itself. The 303(d) listing, as discussed previously, is based on data from the gage site immediately below the Reservoir, and since the Reservoir was constructed it is the controller of pH at the gage. At this point in the stream, as Reservoir operations have been modified and the pH target is now demonstrably being met, a MOS for load allocation computation is moot. Reservoir operations should be conducted so as to ensure ongoing attainment of the pH target, taking into account variability in weather and eutrophication conditions.

(1.4j) Seasonal Variation and TMDL Time Frame

The critical season in which the pH TMDL applies is the time frame in which the 90^{th} percentile pH is outside of 6.5-9.0, at any given site. Historically, this occurs June through September. The seasonal pH pattern is portrayed in **Appendix E**, **Figure E-2**.

(1.4k) Reserve Capacity

Reserve capacity for the Willow Creek pH TMDL is not specified. In the event of population growth or new sources of discharge, activities or discharges should be constrained as needed to support attainment of the pH water quality standard.

Water Quality Standard Attainment Analysis

Repeated summer monitoring for pH has been conducted at eleven sites distributed along Willow Creek. Of these, pH standard exceedance is documentable at two sites (**Appendix E: Figure E-8,** river mile 44 and 55.6 in **Figure E-3**). Attainment of the standard at the upper site, the basis for 303(d) listing, has been achieved through the Willow Creek Reservoir aeration program of the USACE (**Appendix E: Figure E-5**). At the lower site, it is expected that natural flow, channel morphology and vegetation would lead to light and heat conditions in support of reduced summer afternoon pH, and the measured exceedance is slight (based on minimal monitoring data - maximum pH of 9.16).

1.5 TMDL FOR BACTERIA

The Department is addressing bacteria for the Balm Fork of Willow Creek through a gross allotment approach. The technical assessment and basis for this approach is described in **Appendix F** along with data evaluation and summary. The Willow Creek Subbasin, point sources and 303(d) listings are described in **Section 1.2**. **Table 1.5-1** summarizes the bacteria TMDL.

> Technical background and explanation are included in Appendix F, including discussion of terms such as *log mean* and *counts per deciliter* and information regarding bacteria types and water quality criteria.

Though existing data are evaluated (**Appendix F**), the Department has decided not to issue a load allocation addressing the Willow Creek mainstem due to insufficiency of data, limited resources and the lack of a 303(d) listing. Available fecal coliform data suggests bacteria levels exceeding current standards, however, the data type, quantity and timing does not lend itself to robust conclusions. The details of this decision are listed in **Section F-8** of **Appendix F**. The decision is further supported by the fact that an Agricultural Water Quality Management Area plan addresses bacteria Subbasin wide.

Table 1.5-1. *Bacteria TMDL Summary Information*

Water body	Willow Creek Subbasin, Hydrologic Unit Code #17070104. Water body is Balm Fork.
Water Quality Standard	OAR 340-041-009 (Bacteria)
Applicable Water Quality Standard Criteria	Freshwater criteria – log mean 126 counts/deciliter (targeted explicitly), instantaneous 406 counts/deciliter (targeted narratively)
Target Pollutant / Loading Capacity	E. Coli – counts per day
TMDL Surrogate	20 percent reduction (annual log mean)
Existing Pollutant Sources	Livestock, rural residential, natural
Margin of Safety	Ten percent reduction in log mean concentration
Reserve Capacity	None

(1.5a) Name, Location and 303(d) Listings

Refer to **Section 1.2** for 303(d) listings and Subbasin information. The Balm Fork is the only water body in the Willow Creek Subbasin that is listed for bacteria. This TMDL targets that listing. The location of the Balm Fork is shown in **Section 1.2**, **Figure 1.2-1**. Aerial imagery with monitoring locations is provided in the monitoring appendix (**Appendix C**).

(1.5b) Pollutant and Target Identification

The pollutant addressed through this TMDL is fecal coliform bacteria. The numeric target is the log mean fresh water criterion for *E. coli* concentration; 126 organisms per 100 milliliter. The instantaneous criterion of 406 *E. coli* organisms per 100 milliliter is considered in TMDL implementation as well. Ongoing exceedance of instantaneous criteria should be addressed in the TMDL Implementation Plan in the event that management addressing the log mean criteria is not sufficient. Bacteria concentrations in this document are generally expressed in counts/deciliter (counts/dl), units that are equivalent to organisms per 100 milliliter.

(1.5c) Water Quality Standards and Beneficial Uses

In freshwater such as the Balm Fork, the beneficial use affected by elevated bacteria levels is primary water contact recreation. The freshwater bacteria standard is designed to protect the recreational use of waters. It is set at a level that would not exceed concentrations determined through epidemiological studies to cause illness through body contact at a rate of 8 or more cases per 1,000 swimmers. The criteria for "recreational contact in water" apply to all waters in the Willow Creek Subbasin. Beneficial uses in the Subbasin are defined in the Oregon Administrative Rules, OAR 340–041–0310, and are listed in **Recall Table 1.2-1** below.

Recall Table 1.2-1. *Designated Beneficial Uses, Umatilla Basin, including Willow Creek Subbasin (OAR 340-41-0310, Table 310A). The use most sensitive to bacteria pollution is highlighted.*

Beneficial Uses	Umatilla Subbasin	Willow Creek Subbasin
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X (at mouth)
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	X
Commercial Navigation & Transportation		

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.
[2] See also Figures 310A and 310B for fish use designations for this basin.
Table produced November, 2003

The indicator bacterium used by DEQ for assessing bacterial contamination for recreational waters was changed in 1996 from the general class of fecal coliform bacteria to *Escherichia coli (E. coli)*, a species only associated with warm-blooded vertebrates. *E. coli* are a subset of the fecal coliform bacteria group. This change was made in part because *E. coli* is a more direct reflection of contamination from sources that carry pathogens harmful to humans and is correlated more closely with human disease. Fecal coliform bacteria are still used in the standard as the indicator for protection of human health in assessing water quality in commercial and recreational shellfish harvesting areas (brackish and salt waters).

Applicable numeric and narrative criteria for Oregon's bacteria water quality standard are as follows:

(OAR 350-041-0009, gray shaded where not applicable in Willow Creek Subbasin):

(1) Numeric Criteria: Organisms of the coliform group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (a) and (b) of this paragraph.

(a) Freshwaters and Estuarine Waters Other than Shellfish Growing Waters:

(A) A 30-day log mean of 126 E. coli organisms per 100 ml, based on a minimum of five (5) samples;

(B) No single sample shall exceed 406 E. coli organisms per 100 ml.

(b) Marine Waters and Estuarine Shellfish Growing Waters: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 organisms per 100 ml.

(2) Raw Sewage Prohibition: No sewage shall be discharged into or in any other manner be allowed to enter waters of the state unless such sewage has been treated in a manner approved by the Department or otherwise approved by these rules;

(3) Animal waste: Runoff contaminated with domesticated animal wastes must be minimized and treated to the maximum extent practicable before it is allowed to enter waters of the state;

(4) Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or otherwise injurious to public health shall not be allowed;

Additional language in the state water quality standard applies to NPDES permits, sanitary sewer overflows and to facilities with combined sanitary and storm sewers. These provisions are not included here because such facilities do not exist in the Balm Fork watershed. The abbreviation *MPN* above is for 'most probable number' and *ml* is for 'milliliter.'

(1.5d) Loading Capacity

Loading capacities for the Balm Fork, targeting the 30-day log mean criteria, are listed in **Table 1.5-2**. The various flows shown are those measured on the days that monitoring was conducted, at the USGS gage station near the mouth of Balm Fork. As monitoring was conducted year round during a fairly normal water year, this is a representative array of annual flows. Loading capacities are calculated as follows:

LC = 126 counts/dl * Q * CF

Where

LC = loading capacity in counts per day
Q = daily average stream flow (cubic feet per second)
CF = conversion factor = dl/feet^3 * second/day = 283.1 * 86400 = 2.45E7

Table 1.5-2. *Loading capacities at flows associated with sampling*

Flow (cubic feet per second)	Loading Capacity (10^9 counts/day)	Loading Capacity minus 10% MOS (10^9 counts/day)
21.0	64.7	58.3
15.0	46.2	41.6
11.0	33.9	30.5
9.4	29.0	26.1
4.7	14.5	13.0
4.5	13.9	12.5
2.5	7.7	6.9
2.3	7.1	6.4
1.2	3.7	3.3
0.6	1.9	1.7
0.5	1.6	1.4
0.1	0.4	0.4

(1.5e) Excess Load

Excess load is assessed at twenty percent, based on an extended time interval spatial-aggregate log mean. As described in **Appendix F**, the data collection frequency was insufficient to allow for calculation of five-sample 30-day log means called for in the standard. Load duration curves with raw data and extended log means are available in **Appendix F**, plotted with log mean and instantaneous criteria, providing graphic illustration of excess load. The selected method to characterize the excess load (amount of reduction needed to attain loading capacity) is via a gross allotment of the spatially and temporally aggregate *E. coli* data set for Balm Fork, using an annual log mean:

Balm Fork Annual TMDL Excess Load

- Annual log mean *E. coli* = 141 counts/deciliter (aggregate 1996-2001 data from all Balm Fork & Gilman Canyon sites)
- Monthly log mean water quality standard = 126 counts/deciliter
- 10 % margin of safety = 13 counts/deciliter
- Adjusted log mean water quality target = 126-13 =113 counts/deciliter
- 100*113/141 = 20 % reduction to achieve water quality goal

For daily maxima, refer to the loading capacity and load allocations specified in **Sections 1.5d** and **1.5h**.

(1.5f) Pollutant Sources and Jurisdictions

Land use in Balm Fork is entirely agricultural and rural residential. The agency with general jurisdiction for water quality issues and improvements is the Oregon Department of Agriculture. DEQ and the Morrow County have jurisdiction with regard to septic systems.

It is expected that pollutant sources are primarily related to human activities. Natural bacteria inputs to the Balm Fork are likely much less than existing loading. Median concentrations in nearby forested upper watersheds are between two and three orders of magnitude lower than those measured in Balm Fork (**Appendix F**). The only other apparent potential sources are livestock and the less than ten residences in the watershed. It is further discussed in **Appendix F** that sources are likely widespread and with varied modes of delivery, based on the patterns seen in load duration curves and longitudinal box plots. Exceedance is seen at all flow levels. While the correlation between flow and concentration is poor, seasonal patterns are distinctive (**Appendix F**), suggesting that land use/management timing plays a critical role.

(1.5g) Wasteload Allocations (point sources)

No wasteload allocations are assigned, given that there are no NPDES sources in the Balm Fork watershed.

(1.5h) Load Allocations, Surrogates and Measures of Progress

As described previously, loading capacities are generally distributed in one of more of the following categories: point sources (wasteload allocations), human nonpoint sources (load allocation), natural background (also load allocation), reserve capacity and margin of safety. In the Balm Fork, given the rural character of the watershed and low regional growth rate, no reserve capacity is assigned. A ten percent margin of safety in applied (**Section 1.5i**). Because natural background is assessed as negligible relative to the existing loads (background site concentrations from neighboring watersheds are less than one percent of the Balm Fork measurements, **Appendix F**), no load allocation is attributed to natural background. In addition, there are no point sources in the Balm Fork watershed.

Accordingly, the load allocation is ninety percent of the loading capacity, and is attributed to human-related activities (anthropogenic sources). The load allocations for specified flows are listed in **Table 1.5-2** (loading capacity minus ten percent, in counts per day). Load allocation attainment would be assessed at the gage site near the mouth of Balm Fork. The formula used to calculate the LA is as follows, and could be used to account for other flows as well:

LA = 0.9 * WQT * Q * CF

Where LA = Load Allocation (counts/day)
0.9 accounts for ten percent margin of safety
WQT = water quality target (126 counts/deciliter)
Q = flow (feet^3/second)
CF = conversion factor = deciliter/feet^3 * seconds/day = 283.1 * 86400 = 2.45E7

A surrogate measure of load allocation implementation is a twenty percent reduction in the aggregate annual log mean of all six established monitoring sites (**Appendix. C**, **Figure C-2**) in a given year, with a minimum of five monitoring events per year at each site, including the months with high past concentrations. The reader is referred to the *excess load* described in **Section 1.5e**.

(1.5i) Margin of Safety

A ten percent margin of safety is used in the calculation of excess load and loading capacities (**Section 1.5h**).

(1.5j) Seasonal Variation and TMDL Time Frame

Regular exceedance of the instantaneous criterion is of concern, whereas infrequent exceedance probably does not represent beneficial use impairment. This can be assessed via the seasonal (monthly) box plots of **Figures F-14 and F-15** in **Appendix F.** Based on comparing Balm Fork 75th percentiles (all sites aggregated, upper shoulder of box) *E. coli* concentration data with the instantaneous target of 406 counts per deciliter, it can be said that this criteria has been routinely exceeded in June, July, August and October, with insufficient data to assess September and November. Fecal coliform 75th percentile concentrations have exceeded the correlated value of 443 organisms per deciliter in May, July, August and November, with insufficient data to assess December through March. In December, *E. coli* concentrations have exceeded the log mean criteria of 126 organisms per deciliter, and the single available sample from March, for fecal coliform, measures 540 organisms per deciliter. On the other hand, in January and February both the instantaneous and log mean E. coli criteria are not exceeded by any single fecal coliform or *E. coli* analysis.

Based on this review, the priority time frame to target for TMDL implementation and further evaluation is March through December, though the TMDL percent-reduction surrogate is based on the available year-round data set. As a precautionary measure, the load allocation and surrogate apply year round.

(1.5k) Reserve Capacity

In the Balm Fork, given the rural character of the watershed and low regional growth rate, no reserve capacity is assigned. In addition, there are no new or proposed NPDES sources, nor do any seem likely in the future.

Water Quality Standard Attainment Analysis

The decennial reduction trend for *E. coli* suggests the question – is the current rate of reduction sufficient or likely to continue? Due to uncertainties regarding water quality trends and the effectiveness of management changes over the last 5-8 years, the likelihood of sustained reduction can only be speculative. Regarding the current rate of bacteria concentration reduction, it would take several hundred years to meet the water quality standard (inset below), and it is improbable that the rate would be consistent. The strategy for attainment for this TMDL will be encouragement of bacteria-focused implementation of the Agricultural Water Quality Management Area Plan, accompanied by long term monitoring.

> The Sen-Thiel-Kendall line slope (-0.0102, **Appendix F**) for fecal coliform is utilized to assess the trend toward water quality standard attainment, given that the *E. coli* data record is of insufficient duration. This is only calculated as a very rough screen of the adequacy of the current trend. The Department recognizes that neither the rate nor effectiveness of change in watershed management leading to bacteria reduction is likely to be linear.
>
> The 90th percentile of the aggregate *E. coli* data set for Balm Fork is 2218 counts/deciliter. Assuming the same trend for *E. coli* as for fecal coliform, the time for the 90th percentile of *E. coli* to meet the instantaneous criteria of 406 counts/deciliter is calculated: (2218-406)/(-0.0102) = time until attainment. Converted from the Gregorian-based value of 177,647 produced by this equation, the elapsed time would be 486 years.

Though this is better than an increasing trend, much more effective reduction should be feasible. It is again noted here that considerable progress may or may not have been made since 2001. Bacteria reduction is generally correlated to the emplacement of strategic management practices, and dramatic improvements can take place within a single year’s time.

1.6 Public Participation

The Morrow Soil and Water Conservation District, in Heppner, provided an outreach forum and coordinated monitoring with landowners. Over the course of several years, approximately ten advertised public presentations were provided for discussion of TMDL development prior to the formal public comment period. The Department worked with local landowners on several occasions, including voluntary monitoring and in-depth discussions. DEQ staff met with County Commissioners and permitted discharge facility owner/operators. The final stage of outreach for TMDL development is the public comment period held during the summer of 2006, including one public hearing. The public response has been generally affirming of the TMDL development process.

1.7 Literature Cited

The citations here are specific to **Part 1**. Other citations in **Part 1** can be found in the **Literature Cited** section of **Appendix D**. Legal and regulatory references include the **Federal Clean Water Act of 1972**, **40 Code of Federal Regulations**, the **Oregon Administrative Rules** and the **NPDES permits** and **permit evaluations.** The federal and state statutes, rules and permit files are available either on-line, in public libraries or through the DEQ offices in Portland and Pendleton, Oregon.

Cascade Earth Sciences, August 2003. Preliminary Impact Assessment for Proposed Rapid Infiltration Gallery Port of Morrow Generating Facility, Heppner, OR. PN:2322007/August 2003.

Larson, Douglas, W. 1997. Limnological and Water Quality Studies 1984-1996, Final Report (to US Army Corps of Engineers).

Mullan, John, 1858. *Report on the Construction of a Military Road from Fort Walla Walla to Fort Benton,* Ye Galleon Press, Fairfield, Washington.

EPA. January, 2002. *TMDL Review Guidelines*. US Environmental Protection Agency, Region 10.

US Environmental Protection Agency. 1998. *Report of the Federal Advisory Committee on the Total Maximum Daily Load Program*. EPA 100-R-98-006.

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Part Two

Water Quality Management Plan

Willow Creek Reservoir

Willow Creek Valley Above Reservoir

Framework Plan for implementing the Willow Creek Subbasin Total Maximum Daily Load Allocations for temperature, pH and bacteria

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Background

A Total Maximum Daily Load (TMDL) defines the amount of a pollutant that can be present in a water body while meeting water quality standards. A Water Quality Management Plan (WQMP) is developed by DEQ as a broad strategy for implementing TMDL allocations. TMDLs, WQMPs and associated planning work together to protect designated beneficial uses, such as aquatic life, drinking water supplies, and water contact recreation.

In December of 2002, the State of Oregon's Environmental Quality Commission (EQC) adopted a rule commonly referred to as the "TMDL rule" (OAR 340-042). The TMDL rule defines DEQ's responsibilities for developing, issuing, and implementing TMDLs as required by the federal Clean Water Act (CWA). The WQMP is one of the twelve TMDL elements called for in the TMDL rule. Oregon Administrative Rule 340-042-0040-(4)(l) states the following:

> *(l) Water quality management plan (WQMP). This element provides the framework of management strategies to attain and maintain water quality standards. The framework is designed to work in conjunction with detailed plans and analyses provided in sector-specific or source-specific Implementation Plans.*

Introduction

This WQMP lays out strategies for implementing the Willow Creek Subbasin TMDLs documented in **Part 1**. As indicated above, two scales of planning are addressed. The WQMP itself serves as a multi-sector framework plan for the entire Subbasin. It describes and references various plans and programs that are specific to a given land use or management sector. The sector-specific plans, or *TMDL Implementation Plans*, comprise a second tier of planning prepared by the local land use or water quality authority. This organizational process is represented schematically in **Figure 2-1**.

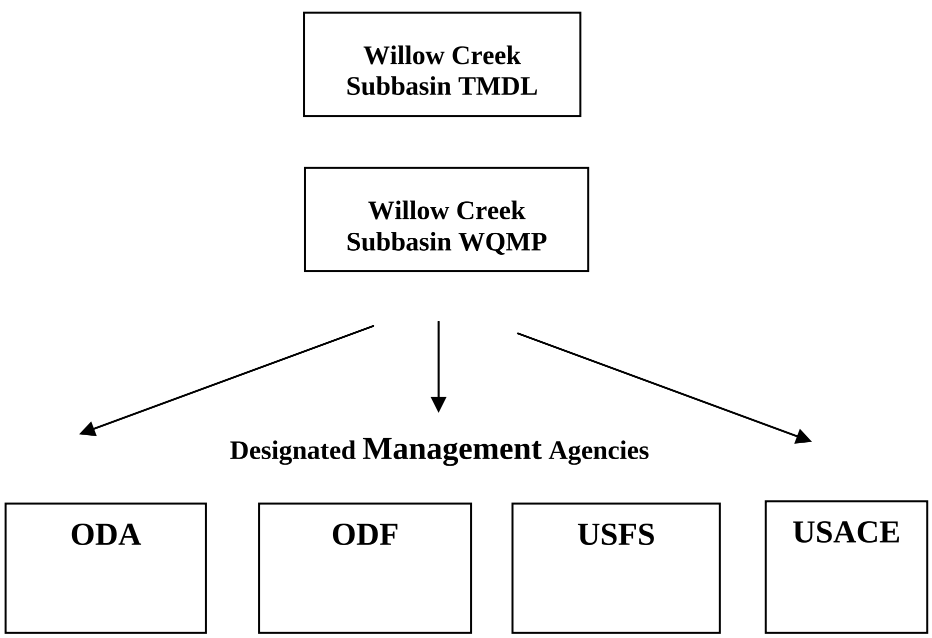

Figure 2-1. *TMDL/WQMP/Implementation Plan Schematic. Agency abbreviations are for: Oregon Departments of Agriculture and Forestry, US Forest Service and US Army Corps of Engineers.*

This WQMP addresses the entire Willow Creek Subbasin. The TMDL Implementation Plans, when complete, are expected to fully describe the efforts of Designated Management Agencies (DMAs) to achieve their applicable TMDL allocations. Because the DMAs will require some time to fully develop these Implementation Plans once the TMDLs are finalized, the first iterations of the Implementation Plans are not expected to completely describe management efforts.

This WQMP establishes timelines to develop Implementation Plans. DEQ and the DMAs will work collaboratively to assure that the WQMP and TMDL Implementation Plans collectively address the elements described below under "TMDL Water Quality Management & Implementation Plan Guidance". In short, this document is a starting point and foundation for the WQMP elements being developed by DEQ and the DMAs.

DEQ recognizes that the relationship between management actions and pollutant load reductions is often not precisely quantifiable. An ***adaptive management*** approach is encouraged, including interim objectives and feedback through monitoring. This is addressed in **Implementation and Adaptive Management** section, preceding **Part 1**.

Water Quality Management & Implementation Plan Guidance

The TMDL rule of OAR 340-042 lists the required elements of a WQMP. This WQMP is intended to fulfill the requirement of the rule. These elements, identified below, serve as the outline for this WQMP.

WQMP Elements

A. Condition assessment and problem description
B. Goals and objectives
C. Proposed management strategies
D. Timeline for implementing management strategies
E. Relationship of management strategies to attainment of water quality standards
F. Timeline for attainment of water quality standards
G. Identification of responsible participants or DMAs
H. Identification of sector-specific Implementation Plans
I. Schedule for preparation and submission of Implementation Plans
J. Reasonable assurance
K. Monitoring and evaluation
L. Public involvement
M. Planned efforts to maintain management strategies over time
N. Costs and funding
O. Citation to legal authorities

A final section, **TMDL-Related Programs, Incentives and Voluntary Efforts**, recognizes the importance of related programs and initiative-based efforts in watershed restoration.

TMDL Implementation Plan – Expected Components

Some of the elements listed above are sufficiently addressed in the WQMP and others are partly or largely deferred to the DMA programs. The TMDL Implementation Plans need not further elaborate upon elements E, G, H, I, and O. The Oregon Administrative Rules in OAR 340-042 clarify DEQ's expectation of TMDL Implementation Plan content, as follows:

> 340-042-0080(2): "The Oregon Department of Forestry will develop and enforce Implementation Plans addressing state and private forestry sources as authorized by ORS 527.610 through 527.992 and according to OAR chapter 629, divisions 600 through 665. The Oregon Department of Agriculture will develop Implementation Plans for agricultural activities and soil erosion and enforce associated rules as authorized by ORS 568.900 through 568.933 and according to OAR chapter 603, divisions 90 and 95."
>
> 340-042-0080(3): "Persons, including DMAs other than the Oregon Department of Forestry or the Oregon Department of Agriculture, identified in a WQMP as responsible for developing and revising sector-specific or source-specific Implementation Plans must:
>
> (a) Prepare an Implementation Plan and submit the plan to DEQ for review and approval according to the schedule specified in the WQMP. The Implementation Plan must:
>
>> (A) Identify the management strategies the DMA or other responsible person will use to achieve load allocations and reduce pollutant loading;
>>
>> (B) Provide a timeline for implementing management strategies and a schedule for completing measurable milestones;
>>
>> (C) Provide for performance monitoring with a plan for periodic review and revision of the Implementation Plan;
>>
>> (D) To the extent required by ORS 197.180 and OAR chapter 340, division 18, provide evidence of compliance with applicable statewide land use requirements; and
>>
>> (E) Provide any other analyses or information specified in the WQMP.
>
> (b) Implement and revise the plan as needed.

The following **Sections C, D, F, H, I, K**, **M and N** include further discussion regarding TMDL Implementation Plan Content.

General discussion of the expected content of TMDL Implementation Plans can be found in *Guidance for Developing Water Quality Management Plans that will Function as TMDLs for Nonpoint Sources*, DEQ, 1997. Nonpoint source pollution reduction measures are described in *Nonpoint Source Pollution Control Guidebook for Local Government*, DEQ and Oregon Department of Land Conservation and Development, 1994. More recent guidance for urban settings is available on the DEQ website http://www.deq.state.or.us/wq/, including the *Water Quality Model Code and Guide Book*, DEQ and Oregon Department of Land Conservation and Development, 2000. Most Federal and State natural resource agencies publish watershed planning guidance as well.

(A) Condition Assessment and Problem Description

In brief, the issue of concern is that the water quality standards are not being met perennially in much of the Subbasin. The temperature standard is exceeded during the summer in much of the Willow Creek Subbasin stream network. The pH standard has been exceeded near Heppner and Lexington, though much progress has been made in mitigating this through de-stratification of the Willow Creek Reservoir. *E. coli* concentrations well in exceedance of the bacteria standard have been documented in the Balm Fork. A description of the Subbasin is provided in **Section 1.2** of **Part 1**. **Part 1** also provides goals for each pollutant parameter. The temperature objectives and current summer temperature and heating profiles are shown in **Sections 1.3b** and **1.3h**. **Section 1.3f** summarizes the assessed causes of excess stream heating. The goals for bacteria reduction are provided in **Section 1.5**. The need for ongoing moderation of Reservoir pH, as well as nutrient limits for point sources and additional pH-related monitoring near Lexington, is discussed in **Section 1.4**.

(B) Goals and Objectives

The overarching goal of this WQMP is implement TMDLs to address the 303(d) listings and related impairment found in the Willow Creek Subbasin. This will be achieved by:

- improving riparian and channel conditions (nonpoint source)
- maintenance of Reservoir pH and temperature within criteria
- NPDES limits for the two permitted discharge facilities – temperature, pH, nutrients (point source)
- reducing bacterial inputs to Balm Fork (nonpoint source)
- instream flow restoration is encouraged as well, where flow regimes have been artificially reduced.
- Through the above, targeting the TMDL allocations

(C) Proposed Management Strategies

DEQ acknowledges that restoration and conservation planning and implementation has commenced, in a manner supportive of TMDL attainment. And, in much of the Subbasin, more restoration is needed and long term planning should provide for maintenance of effort over time, including areas where the load allocations are currently being met. As described previously, DEQ is reliant on the DMAs for programs and projects providing strategies to minimize stream heating. The following is a list of conditions for management agencies to target:

<u>Perennial streams subbasin-wide</u>

- Healthy riparian vegetation, including shade producing types. There is potential for continuous stands of riparian trees and herbaceous vegetation along most of the Subbasin perennial streams, though in some situations this will require considerable evolution in channel shape. This could take decades, and simultaneous improvement of vegetation and channel will provide incremental benefit as enable natural morphologic development. Potential shade producing vegetation is described and referenced in **Part 1**, **Section 1.3h**. Though DEQ does not specify required vegetation types, for overall ecological benefits and consistency with programs directed to fish and wildlife habitat restoration, native vegetation is generally optimal.
- A stable and natural channel form that will typically be narrower and/or more complex than the existing state. Passive or active restoration could be applied. Potential channel types and widths are discussed in **Part 1**, **Section 1.3h** and **Appendix D**.
- Increased sinuosity, leading to attainment of a more natural channel width/depth.
- Upland management that reduces erosion and sediment runoff, supporting attainment of a more natural channel form.

- Increased instream flow, where depleted, will ultimately be needed to achieve the water quality standard for temperature. Note that the TMDL calls for heat reduction, and though we recommend restored flow levels as well, increased flow is not an objective required by the TMDL.
- Increased area of functioning floodplains.

Mainstem below Willow Creek Reservoir

- pH controls and monitoring. The TMDL issues a numeric target of 6.5 – 9.0 pH for Reservoir outlet flow. Example management strategies include (USACE):
    - ongoing use and timing of aeration system
    - strategic control of withdrawal depth in relation aeration schedule
- Below Heppner, temperature TMDL implementation will support pH moderation, however ongoing monitoring will be needed to evaluate sufficiency (various natural resource organizations)
- Point source monitoring and limiting nutrient loads.

Balm Fork

- *E. coli* (Balm Fork) controls and monitoring are needed. Best management practices addressing livestock and septic systems should be applied through the watershed, particularly along the major waterways. Example management strategies include:
    - Further evaluation of septic systems (DEQ)
    - Livestock fencing of riparian areas
    - Re-location of animal feedlots near stream, off channel watering and feeding

Management strategies should include outreach, effectiveness monitoring and inventory and tracking of water quality management practices. Implementation Plans should identify targeted TMDL allocations and the sources of water quality impairment addressed by proposed measures.

(D) Timeline for Implementing Management Strategies

Individual TMDL Implementation Plans will address timelines for completing measurable milestones as appropriate. Time frames for TMDL attainment and Implementation Plan submittal are addressed in **Sections F** and **I** of **Part 2**.

NPDES permits are scheduled for re-evaluation/issuance each five years.

DEQ recognizes that natural resource organizations, local jurisdictions and landowners have been active in watershed restoration both directly and through outreach. This report does not attempt a timeline addressing the many ongoing and voluntary efforts.

(E) Relationship of Management Strategies to Attainment of Water Quality Standards

For point sources of pollution, ODEQ will issue permits that include specific discharge limitations and compliance schedules that ensure water quality standards are met or will be attained within a reasonable timeline. Permits are reviewed and renewed on a 5-year cycle.

Riparian vegetation and channel shape substantially and quantifiably influence stream heating. **Figures 1.3-1** and **1.3-4** of **Part 1** illustrate the temperature and heat loading profiles for various configurations of vegetation and channel form. **Sections 1.5e** and **1.5f** of **Part 1** quantify excess load and discuss sources of pollutants for bacteria. **Appendices D, E and F** provide further information documenting the relationships between pollutant levels and strategies in the Willow Creek Subbasin. The temperature TMDL objective is the natural thermal potential that would be attained when solar heating is reduced to the level of the load allocations, as accomplished by improving vegetation and channel conditions. Bacteria and pH will likely require ongoing improvement and assessment to relate loads to practices.

The temperature water quality standards (natural condition criteria) will be met as load allocations are attained, if sufficient stream flow restoration occurs. Management strategies should be clearly linked to the load allocations and their surrogates.

DMAs are expected to prepare an annual report and undertake an evaluation of the effectiveness of their plans every five years to gauge progress toward attaining water quality standards. If it is determined that an Implementation Plan is not sufficient to achieve the load allocation, the DMA will be required to revise the plan accordingly. All of these actions, taken together, will target attainment of water quality standards.

(F) Timeline for Attainment of Water Quality Standards

The timeline for attainment is not explicit and will vary across the Subbasin and by pollutant. Refer to **Part 1, Water Quality Standard Attainment Analysis**, for further discussion of time-lines. DEQ expects that water quality standards will be attained as soon as feasible given technical, political, and economic constraints.

DMAs are expected to provide time-lines for TMDL implementation efforts. In subsequent TMDL and Implementation Plan review, this should enable estimation of time frames for water quality standard attainment.

(G) Identification of Responsible Participants or DMAs

The purpose of this element is to identify the organizations responsible for the implementation of the Willow Creek Subbasin TMDL (**Table 2-1**). A more detailed discussion of each organization's responsibilities is provided in **Section H**.

DMAs are defined as "federal, state or local government agency that has legal authority over a sector or source contributing pollutants, and is identified as such by the DEQ in a TMDL" (OAR 340-042). To the extent the term DMA is applied to organizations responsible for TMDL Implementation Plans or programs, the DMAs for the Willow Creek Subbasin TMDL are: ODA, ODF, USACE, and the Umatilla National Forest. Municipalities also share in TMDL implementation responsibility and are discussed in this and following sections, but are not required to submit TMDL Implementation Plans at this time. Also with regard to TMDL responsibilities, DEQ recognizes that organizations are not responsible for land use activities or load allocations outside of their area of jurisdictional authority.

Part 1, **Figures 1.2.7 and 1.3-6** indicate the geographic areas of responsibility along the simulated corridor of Willow Creek for various land uses to which the temperature TMDL applies. On other perennial, or potentially perennial, tributaries and the upper most Willow Creek agriculture and forestry dominate, including private and federal forestry. For these land uses, the jurisdiction is clear: ODA for agriculture, ODF for non-Federal forest and USFS for Federal forests. For bacteria concerns, the geographic area is the Balm Fork watershed and the water quality jurisdictional organization is generally ODA. With regard to septic systems, DEQ is the responsible agency to ensure that systems are functioning and operated in accordance with rules. Regarding both pH and temperature, responsible parties for TMDL implementation include the USACE for Reservoir operations and the two permittees for individual-facility NPDES sources.

Table 2-1. *List of organizations with TMDL responsibilities*

Management Agency	Area of Jurisdiction	Expected Form of Planning in Response to TMDL
Oregon Department of Agriculture	Agricultural and associated rural residential land use along the mainstem and all perennial tributaries	SB1010 Agricultural Water Quality Management Area Plan, updated as needed in the next periodic review
Oregon Department of Forestry	Conifer and Mixed Forest on non-Federal upper reaches of Willow Creek and major tributaries, outside of the Umatilla National Forest	Ongoing implementation of the Forest Practices Act
US Forest Service	Umatilla National Forest	USFS Water Quality Restoration Plan
US Army Corps of Engineers	Willow Creek Reservoir	Reservoir operations planning documentation that TMDL is addressed

Note that the Cities of Heppner, Lexington and Ione are not required to submit a TMDL Implementation Plan for nonpoint source heating, though they contribute to the warming of Willow Creek. These municipalities constitute the smallest jurisdiction of steam heating in the Subbasin. The Department recognizes that small towns often don't have the resources to develop planning and documentation for TMDL implementation. Alternatively, they could work directly with DEQ via their own initiative, to strategize resources and approaches for TMDL implementation. DEQ and other natural resource organizations, such as the Morrow SWCD, should support municipalities in recruiting funding and producing approaches for nonpoint source heat reduction.

If this initiative-based and collaborative method is sufficient, the Department would not formally assign the cities DMA status in the next review of the TMDL.

This WQMP primarily addresses nonpoint sources. Point sources have minimal contributions and are addressed through permits rather than nonpoint source TMDL Implementation Plans, as discussed in **Part 1**. However, for clarity and completeness point sources are accounted for in the following section.

(H) Existing Planning Framework and Expected TMDL Response

Several organizations utilize existing programs as TMDL Implementation Plans. This is typically documented in a memorandum of understanding or agreement with the DEQ. The following planning efforts provide for TMDL implementation in the Willow Creek Subbasin. DEQ expects that they will be updated as needed to layout all feasible steps toward meeting the TMDL. The sections below describe the general form of the anticipated response to the TMDL. Expected elements of TMDL Implementation Plans are listed previously in the section entitled **Water Quality Management & Implementation Plan Guidance**.

NPDES Permit Program – Point Sources

DEQ administers the National Pollutant Discharge Elimination System (NPDES) permits for surface water discharge; and is delegated to do so by EPA. The NPDES permit is a federal permit, required under the Clean Water Act for discharge of waste into waters of the United States.

Individual-facility NPDES permits are unique to a discharge facility. General NPDES permits address categories of facilities or aggregate pollutant sources, such as fish hatcheries or storm water. As described in **Section 1.2**, there are presently two individual-facility NPDES permit issued in the Willow Creek Subbasin: The City of Heppner Waste Water Treatment Plant and the Oregon Co-Gen, LLC power generation plant. NPDES permit requirements will be modified in response to this TMDL at the time of their next scheduled renewal. Specifically temperature limits will be based on this TMDL and nutrients concentrations will be required to not exceed current levels. Any future permits must address the TMDL as appropriate given their location and season of discharge.

DEQ Expectations. In addition to updating permit effluent limits through the TMDL, monitoring of nutrients is expected, and this requirement has already been placed in the permit for the City of Heppner. Both facilities will need to characterize existing nutrient loading to enable verification through time that these are not exceeded, as called for in the pH TMDL.

Nonpoint Sources

Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality. ODA employs *Agricultural Water Quality Management Area Plans* (AgWQMAP) and associated rules to implement TMDLs throughout the state. Periodic review of the progress of AgWQMAP implementation is called for in rule (OAR 603-090-0020). The AgWQMAP are reviewed biennially.

DEQ and ODA coordinate TMDLs and agricultural planning through a 1998 Memorandum of Agreement (MOA). The MOA states that "*Load allocations for agricultural nonpoint sources will be provided by DEQ to ODA which will then begin developing an AgWQMAP, or modifying an existing AgWQMAP, to address the load allocation*" and, specific to situations where AgWQMAP development has proceeded a TMDL: "*At the time that DEQ develops load allocations for agricultural nonpoint sources or groups of sources, ODA will evaluate the AgWQMAP previously developed plan to assure the attainment of DEQ's load allocations for agriculture*."

Local Management Agencies (LMA) are funded to conduct outreach and education, develop individual farm plans for operations in the planning area, work with landowners to implement management practices, and help landowners secure funding to cost-share water quality improvement practices. The Local Management Agency is the Morrow Soil and Water Conservation District, working under contract to ODA.

Progress reports, which are submitted to the Board of Agriculture after the biennial review process, are developed based on data collected by Local Management Agencies and ODA on progress of implementation of the plans and rules. Reports to the Board of Agriculture and Director will include statistics on numbers of farm plans developed and types of management practices being employed. These reports are available to DEQ for review in assessing implementation progress.

Current Status. The first Willow Creek Subbasin AgWQMAP and rule have been adopted by the Board of Agriculture. A first biennial review was recently implemented by the ODA and the Local Advisory Committee (LAC). The review report concludes that substantive changes were not needed. The

AgWQMAP and Rules are available from ODA's website at: http://www.oda.state.or.us/nrd/water_quality/areapr.html.

DEQ Expectations. DEQ expects that the next biennial review, in 2008, will address the temperature TMDL throughout the Subbasin including Willow Creek and all major tributaries, and the bacteria TMDL for the Balm Fork watershed – including identifying how progress toward achievement of the surrogate measures for load allocations will be approached. Regarding the Balm Fork, it is noted that though the bacteria TMDL is based on a log mean, the *E. coli* instantaneous criterion should not be exceeded as well, with any regularity.

Non Federal Forest Lands

The Oregon Department of Forestry is the DMA for water quality protection from non-point source discharges or pollutants resulting from forestlands on non-federal forestlands in Oregon.

The Forest Practices Act (FPA) applies regional rules to forestlands and also provides for watershed specific protection rules. Watershed-specific protection rules are a mechanism for subbasin-specific TMDL implementation in non-Federal forest land where water quality impairment is attributable to current forest practices. Legacy issues are addressed through management planning with ODF as a participant. Coordination between ODF and DEQ is guided by a Memorandum of Understanding (MOU) signed in April of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the forest practice rules as part of the TMDL process. ODF and DEQ are involved in several statewide efforts to analyze the existing FPA measures and to better define the relationship between the TMDL load allocations and the FPA measures designed to protect water quality.

The TMDL that applies in forest lands is for temperature.

Current Status. DEQ staff reviewed aerial photography and conducted ground level observations along the length of Willow Creek. The forest area in the nonfederal lands area extending 4 miles below Cutsforth Park includes various areas where shade-producing vegetation along Willow Creek appears disturbed. This is indicated by large quantities of down trees and areas of immature trees and, compared to much of the Blue Mountain riparian areas with conifer dominance, low densities of large trees and low effective shade. Computer simulation based on estimates of tree height and density for mature forest stands results in mature forest stands producing significantly less stream heating. Simulated heating could be exacerbated by inaccurate estimates of natural potential. The natural condition of riparian areas in dry forest site conditions and fire prone environments such as upper Willow Creek need further evaluation. Reflecting DEQ's policy of *Implementation and Adaptive Management,* page **vi** of the TMDL states that even where load allocations based on full natural potential are not met, this is permissible in the event of natural disturbance such as drought, fire, disease, etc. Further assessment is needed in order to determine whether the current situation is due to natural forest dynamics. It is also important to recognize that the TMDL focused on the mainstem - the tributaries to Willow Creek were not evaluated in the assessment.

DEQ and ODF joint plan for next steps. Inter-Departmental discussion and evaluation is needed to determine, in the non-Federal forested area of the Sub-basin along all perennial streams: (1) whether unnaturally increased heating is occurring and (2) if so, is the excess heating related to current or past forest practices, or practices unrelated to forestry. Once these questions are answered, a strategy needs to be produced to address any deviations from the natural condition criteria of the Oregon temperature standard.

Umatilla National Forest

The US Forest Service (USFS) is the DMA for federal forest land in the Subbasin. In July 2003, the USFS signed a memorandum of agreement with DEQ defining how water quality rules and regulations regarding TMDLs will be met. The agency generally responds to TMDLs by developing and implementing Water Quality Restoration Plans (WQRPs) which will be the equivalent of TMDL Implementation Plans.

The U.S. Forest Service and BLM have developed a protocol to be used to guide the development of WQRPs (USFS 1999). The WQRPs are revised as needed in order to implement TMDLs.

The TMDL that applies in forest lands is for temperature.

The USFS manages lands in the upper part of the Subbasin, along its southern boundary. This area is administered by the Umatilla National Forest, through the Supervisor's Office in Pendleton, Oregon and the District Office in Heppner, Oregon. As the National Forest lands are outside of the simulated corridor, the Department did not carry out an NTP evaluation of the area.

Current Status. A WQRP has not yet been developed.

DEQ Expectations. DEQ expects submission of a WQRP reflecting evaluation of the forest condition relative to NTP and planning to address any deviations from NTP and long term maintenance of NTP conditions. This is applicable throughout the perennial stream network in the Subbasin's National Forest land area.

Willow Creek Reservoir

Willow Creek Reservoir exerts substantial control over pH and temperature in Willow Creek below the Reservoir.

Current Status. The temperature target for the Reservoir outflow is currently not being met in parts of July and August. Due to in-Reservoir water column mixing associated with the Reservoir aeration project, the pH criteria is achieved perennially at the Reservoir outlet.

DEQ Expectations. Documentation (Implementation Plan) showing ongoing maintenance of pH levels at the Reservoir outlet, within 6.5 to 9.0. Documentation of strategy designed to implement the temperature target and load allocations in the temperature TMDL during the critical period.

(I) Schedule for Submission of Implementation Plans

This section specifies a timeline for the preparation and submission of Implementation Plans by DMAs. In accordance with OAR 340-042-0060, TMDL are issued as a DEQ order, effective on the date signed by the Director. DEQ will notify all affected NPDES permittees and DMAs identified in this document and persons who provided formal comment on the draft TMDL within 20 business days of TMDL issuance. DEQ expects that the USFS, ODF and USACE will fulfill the planning and evaluation expectations of **Section H** with 18 months of the date of receipt of their notification letter. ODA follows a two year timeline from the last AgWQMAP review as specified by rule.

DEQ review and approval of TMDL Implementation Plans is called for in OAR 340-042. Following Implementation Plan submittal, DEQ will work closely with DMAs to ensure a successful and timely review/approval process. In accordance with the MOU, once a USFS plan is received by DEQ, DEQ will provide a letter of approval within 60 days with any appropriate requirements for revision.

The Implementation Plans, this WQMP and the TMDLs are part of an adaptive management process. Review of the TMDLs, WQMP and Implementation Plans will tentatively target a 5-year cycle, but this is subject to available staff time and varying levels of priorities within and outside of DEQ. Evaluations that trigger revision of the Implementation Plans will include, but not be limited to, consideration of: DMA recommendations, the periodic evaluation called for in **Section M**, new 303(d) listings, TMDL revision and other BMP effectiveness and water quality trend evaluations.

(J) Reasonable Assurance

This section of the WQMP is intended to provide reasonable assurance that the WQMP (along with the associated DMA-specific Implementation Plans) will be implemented and that the TMDL and associated allocations will be met. NPDES point sources are addressed through the DEQ and EPA permit program. This Section will focus on nonpoint sources.

Federal Lands
As discussed previously, the USFS is a DMA for federal lands in the Willow Creek Subbasin. The USFS has signed memorandums of agreement with DEQ. This MOA includes agreement to prepare and implement Water Quality Restoration Plans (WQRPs) addressing TMDLs. For further discussion, refer to **Sections H** and **O**.

Non Federal Forest Lands
As discussed previously, the Oregon Department of Forestry (ODF) is the DMA, by statute, for water quality protection from nonpoint source discharges or pollutants resulting from forest operations on non federal forestlands in Oregon. Linkage to TMDLs and legal authority are discussed in **Sections H** and **O**.

Agricultural Lands
As discussed previously, the Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality. AgWQMA Plans are the TMDL implementation mechanism for agricultural and related rural residential land use. As noted in **Section H**, an AgWQMA Plan has been prepared for the Willow Creek Subbasin and ODA has institutionalized a 2-year update cycle.

Voluntary Farm Plans are a key component of the SB1010 planning process. In addition, ODA has the ability to assess civil penalties when local operators do not follow their local Agricultural Water Quality Management Area rules. Legal authority is discussed in **Sections H** and **O**.

Urban and Rural Lands
Oregon cities and counties have authority to regulate land use activities through city and county ordinances and local comprehensive land use plans. The Oregon land use planning system, administered through the Oregon Department of Land Conservation and Development, requires local jurisdictions to address water quality protection through Statewide Planning Goals 5 and 6. Though counties and cites are not identified herein as DMAs, both have potential contributions in preventing possible future point source pollution and both will likely interact with TMDL DMAs on stream-temperature related issues.

Willow Creek Reservoir
The USACE has worked in cooperation with DEQ on preparing the TMDLs and in public outreach. In addition, the USACE is charged with operating its projects in compliance with the federal Clean Water Act, and in accordance with all federal, State, interstate and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water quality pollution as per § 313 (33 U.S.C. 1323). For further discussion of legal authority, refer to (**Section O**).

Voluntary Efforts and Public Funding
Environmental watershed planning in Oregon is supported through outreach, technical assistance, monetary incentives and cost share funding through a variety of organizations and programs (refer to **Sections N** and **TMDL-Related Programs, Incentives and Voluntary Efforts**). As watershed programs continue to develop and more projects are implemented, landowner adoption of water quality practices broadens through increasing knowledge, familiarity and success.

(K) Monitoring and Evaluation

Monitoring and evaluation has three basic components: 1) implementation of TMDL Implementation Plans identified in this document; 2) management practice effectiveness monitoring and, 3) assessment of water quality improvement. DEQ generally expects that DMAs will monitor implementation efforts and that DEQ and various natural resource organizations including DMAs will participate in effectiveness and water quality monitoring.

The information generated by each of these organizations will be pooled and used to determine whether management actions are having the desired effects or if changes in management actions and/or TMDLs are needed. This detailed evaluation (refer to **Section M**) will be planned, as feasible, roughly on a five year cycle. If progress is insufficient, then the appropriate management agency will be contacted with a request for additional action. This monitoring and feedback mechanism is a major component of the "reasonable assurance of implementation" for the Willow Creek Subbasin WQMP.

Although collaborative monitoring capabilities and plans have not yet been developed in response to an approved TMDL, it is anticipated that monitoring efforts will consist of some of the following types of activities:

- Reports on the numbers, types and locations of projects, BMPs and educational activities completed (Subbasin wide)
- In-stream temperature monitoring (Willow Creek, major tributaries)
- Monitoring of channel width and depth (Willow Creek)
- Monitoring riparian vegetation communities and shade to assess progress towards achieving NTP targets established in the temperature TMDL (Subbasin wide)
- Monitoring of pH on Willow Creek (below, in and immediately above Reservoir)
- *E. coli* monitoring (Balm Fork)
- BMP efficacy evaluation

DEQ is currently developing state-wide guidance for Implementation Plan monitoring, including a matrix for tracking implementation efforts (*TMDL Implementation Internal Management Directive,* in draft). As available, DEQ will contribute resources and training to design and/or implement quality water monitoring efforts. Other organizations are encouraged to combine monitoring resources in collaborative approaches.

(L) Public Involvement

Refer to the **Public Participation** section of **Part 1**, for public involvement during TMDL development. Public involvement in implementation will be important as well. Each DMA is responsible for outreach efforts relating to their ongoing land management and TMDL implementation. DEQ is responsible for outreach to cities to apprise them of their role in TMDL implementation, as well as general outreach regarding water quality, 303(d) list and TMDLs.

(M) Maintaining Management Strategies over Time

As addressed in **Section E**, each DMA will review their TMDL Implementation Plan or program for its effectiveness in addressing load allocations. In addition, each DMA will submit an annual report describing the implementation efforts underway and noting changes in water quality. DEQ will review these submittals and recommend changes to individual Implementation Plans if necessary. The 303(d) listing and TMDL process and the management planning associated with WQRP, forest practices and agricultural planning are ongoing by design.

(N) Costs and Funding

One purpose of this element is to demonstrate there is sufficient funding available to begin implementation of the WQMP. Another purpose is to identify potential future funding sources for project implementation. DMAs and other natural resource organizations are implementing numerous natural resource enhancement efforts and projects in the Subbasin which are relevant to the goals of the plan, through a variety of funding sources.

The cost of restoration projects varies considerably and can range from zero cost, or even profit due to improvements, to full channel reconstruction and land acquisition which can cost hundreds of thousands of dollars per river mile. Restoration can be passive or active. Passive restoration results from removing stresses to the channel, vegetation and floodplain and allowing the river system to naturally recover. Active restoration involves channel construction, installation of structures to capture sediment or re-direct water, etc., and tends to cost more than passive. Passive restoration can be accomplished through measures such as fencing or allowing natural vegetation to grow between farm fields and streams. Different measures are appropriate for different management styles, land uses, and types of geomorphic or vegetative impairment. Restoration can be accomplished by simply changing management as a matter of business, such as changing the timing of pasture use. Given these complexities and uncertainties, a cost analysis is not attempted here. Generalized costs for a variety of possible restoration scenarios were estimated for the Umatilla Basin TMDL, with a focus on temperature. The reader is referred to **Chapter 3.5.1** of that document.

Potential Sources of Project Funding

Financial assistance is provided through a mix of cost-share, tax credit, and grant funded incentive programs designed to improve on-the-ground watershed conditions. Some of these programs, due to the sources of their funding, have specific qualifying factors and priorities. The following is a partial list of assistance programs available in the Subbasin.

Program	Agency/Source
Oregon Plan for Salmon and Watersheds	OWEB
Environmental Quality Incentives Program	USDA-NRCS
Wetland Reserve Program	USDA-NRCS
Conservation Reserve Enhancement Program	USDA-NRCS
Stewardship Incentive Program	ODF
Access and Habitat Program	ODFW
Partners for Wildlife Program	USDI-FSA
Conservation Implementation Grants	ODA
Conserved Water Program and other water projects	WRD
Nonpoint Source Water Quality Control (EPA 319)	DEQ-EPA
Riparian Protection/Enhancement	COE
State Revolving Fund low interest loans	DEQ-EPA
Bonneville Power Administration	BPA
Nonpoint Source Pollution Reduction Tax Credit	DEQ

Grant funds are available for water quality improvement projects, typically on a competitive basis. Field specialists assist landowners in identifying, designing, and submitting eligible projects for these grant funds. Assistance is available through the Morrow Soil and Water Conservation District.

(O) Citation of Legal Authorities

Clean Water Act Section 303(d)

Section 303(d) of the 1972 Federal Clean Water Act as amended requires states to develop a list of rivers, streams and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Such water bodies are referred to as "water quality limited". Water quality limited water bodies are identified by DEQ. DEQ updates the list of water quality limited waters every two years. The list is commonly referred to as the 303(d) list. Section 303(d) of the Clean Water Act further requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on the 303(d) list.

Oregon Revised Statute

The Oregon Department of Environmental Quality is authorized by law to prevent and abate water pollution within the State of Oregon pursuant to ORS 468B.015, which declares that it is the public policy of the state to maintain and protect quality of waters of the state. The statute ORS 468B.020 (Prevention of pollution) provides that:

"(1) Pollution of any of the waters of the state is declared to be not a reasonable or natural use of such waters and to be contrary to the public policy of the State or Oregon, as set forth in ORS 468B.015.

(2) In order to carry out the public policy set forth in ORS 468B.015, the department shall take such action as is necessary for the prevention of new pollution and the abatement of existing pollution by:

- (a) Fostering and encouraging the cooperation of the people, industry, cities and counties, in order to prevent, control and reduce pollution of the waters of the State; and
- (b) Requiring the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015 and to conform to the standards of water quality and purity established under ORS 468B.048."

Oregon Administrative Rules

The following Oregon Administrative Rules provide numeric and narrative criteria (water quality standards, discussed in **Part 1**) for stream temperature in the Subbasin:

Antidegradation – OAR 340-041-0004
Statewide Narrative Criteria – OAR 340-041-0007
Temperature – OAR 340-041-0028
pH – OAR 340-041-0021
Bacteria – OAR 340-041-0009

Forest Practices

The Oregon Forest Practices Act (FPA) was enacted in 1971. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describes BMPs for forest operations. The Environmental Quality Commission (EQC), Board of Forestry, DEQ and ODF have agreed that these pollution control measures will be relied upon to result in achievement of state water quality standards. Forest operators conducting operations in accordance with the Forest Practices Act (FPA) are considered to be in compliance with water quality standards. A 1998 Memorandum of Understanding between both agencies guides the implementation of this agreement, as described in **Section H**.

ODF and DEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310 and OAR 629-635-110.

Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality through the Agricultural Water Quality Management Act of 1993 (SB1010, ORS 569.000 through 568.933) and Senate Bill 502 (adopted 1995, ORS 561.191).

SB1010 directs ODA to work with local communities, including farmers, ranchers, and environmental representatives, to develop Agricultural Water Quality Management Area Plans (AgWQMAP) and rules throughout the State. SB502 stipulates that ODA "*shall develop and implement any program or rules that directly regulate farming practices that are for the purpose of protecting water quality and that are applicable to areas of the state designated as exclusive farm use zones or other agricultural lands*." The plans are accompanied by regulations in OAR 603-90 and portions of OAR 603-95, which are enforceable by ODA. As discussed in **Section H**, TMDL implementation coordination between ODA and DEQ is guided by an MOA signed in 1998.

USFS

As discussed in **Section H**, DEQ maintains Memorandums of Agreement with the USFS; signed in July, 2003. The MOA defines processes by which the agency will work with DEQ to meet State and Federal water quality rules and regulations. This agreement recognizes the USFS as the DMA for the lands they administer in Oregon, and clarifies that WQRPs are the TMDL Implementation Plans for this agency.

USACE Dam Operation and Management

In association with other federal statues, including House Document No. 531 Volume V, the River and Harbor Act, the Flood Control Act, and the Water Resources Development Act, the U.S. Army Corps of Engineers (USACE) is charged with operating its projects in compliance with the federal Clean Water Act, and in accordance with all federal, State, interstate and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water quality pollution as per Title 1 Section 313 (33 U.S.C. 1323).

TMDL-Related Programs, Incentives and Voluntary Efforts

TMDLs in Oregon are designed to coordinate with and support other watershed protection and restoration efforts. Watershed enhancement in the Subbasin is ongoing and is, for the most part, consistent with or directly implements the load allocations of the TMDL. While regional programs are in place, much of the restoration is locally based. Collectively these organizations and programs produce technical assistance, financial assistance, restoration opportunities, outreach, discussion forums, incentives and planning.

The Oregon Plan for Salmon and Watersheds

The Oregon Plan for Salmon and Watersheds represents a major process, unique to Oregon, to improve watersheds and restore endangered fish species. The Plan consists of several essential elements:

(1) Coordinated Agency Programs

Many state and federal agencies administer laws, policies, and management programs that have an impact on salmonids and water quality. These agencies are responsible for fishery harvest management, production of hatchery fish, water quality, water quantity, and a wide variety of habitat protection, alteration, and restoration activities. Previously, agencies conducted business independently. Water quality and salmon suffered because they were affected by the actions of all the agencies, but no single agency was responsible for comprehensive, life-cycle management. Under the Oregon Plan, all government agencies that impact salmon are accountable for coordinated programs in a manner that is consistent with conservation and restoration efforts.

(2) Community-Based Action
Government, alone, cannot conserve and restore salmon across the landscape. The Oregon Plan recognizes that actions to conserve and restore salmon must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done. Government programs will provide regulatory and technical support to these efforts, but local people will do the bulk of the work to conserve and restore watersheds. Education is a fundamental part of the community based action. People must understand the needs of fish and wildlife, and how rivers function, in order to make informed decisions about how to make changes to their way of life that will accommodate clean water and the needs of fish.

(3) Monitoring
The monitoring program combines an annual appraisal of work accomplished and results achieved. Work plans will be used to determine whether agencies meet their goals as promised. Biological and physical sampling will be conducted to determine whether water quality and salmon habitats and populations respond as expected to conservation and restoration efforts.

(4) Appropriate Corrective Measures
The Oregon Plan includes an explicit process for learning from experience, discussing alternative approaches, and making changes to current programs. The Plan emphasizes improving compliance with existing laws rather than arbitrarily establishing new protective laws. Compliance will be achieved through a combination of education and prioritized enforcement of laws that are expected to yield the greatest benefits for salmon.

Landowner Assistance Programs
A variety of grants and incentive programs are available to landowners in the Subbasin. These incentive programs are aimed at improving the health of the watershed, particularly on private lands. They include technical and financial assistance, provided through a mix of state and federal funding. This assistance is administered by several organizations, including but not limited to: the Morrow County Soil and Water Conservation District, the Oregon Department of Forestry, the Oregon Department of Agriculture, the Oregon Department of Fish and Wildlife, DEQ, and the National Resources Conservation Service. These services include on-site evaluations, technical project design, stewardship/conservation planning, and referrals for funding. This assistance and funding is further assurance of implementation of the TMDL WQMP. A list of funding sources or programs is provided in **Section N**.

Natural Resource Agencies
Several Natural Resource Agencies have active restoration, protection and monitoring programs in the Basin, including: OWRD, ODFW, ODA, DEQ, Umatilla National Forest, USACE.

Literature Cited

The citations here are specific to **Part 2**.

USDA Forest Service, USDI Bureau of Land Management, Environmental Protection Agency, 1999. *Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d) Listed Waters*.

DEQ, 1997. *Guidance for Developing Water Quality Management Plans that will Function as TMDLs for Nonpoint Sources*.

DEQ and Oregon Department of Land Conservation and Development, 1994. *Nonpoint Source Pollution Control Guidebook for Local Government*.

DEQ and Oregon Department of Land Conservation and Development, 2000. *Water Quality Model Code and Guide Book*, http://www.deq.state.or.us/wq/.

DEQ
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Appendix A: Abbreviations

BLM	United States Bureau of Land Management
BOD	Biological Oxygen Demand
BOD_5	Biological Oxygen Demand in a sample over a 5-day incubation period
ºC	Degrees Celsius
c	Heat Capacity
cal	Calorie
cm	Centimeter
CFS	Cubic Feet Per Second
CMS	Cubic Meters Per Second
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DIN	Dissolved Inorganic Nitrogen (nitrite+nitrate+ammonia)
dl	Deciliter (100 milliliters)
DMA	Designated Management Agency
DO	Dissolved Oxygen
DOQ	Digital Orthophoto Quadrangle
d/s	Downstream
E. Coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
ºF	Fahrenheit
FLIR	Forward Looking Radiometry (synonym for Thermal Infrared Radiometry)
GIS	Geographic Information Systems
GPS	Global Position Sensor
HUA	Human Use Allowance
HUC	Hydrologic Unit Code
J	Joule
km	Kilometer
LA	Load Allocation
LC	Loading Capacity
m	Meter
ml	Milliliter
MAO	Mutual Agreement and Order
MOU	Memorandum of Understanding
MOA	Memorandum of Agreement
MOS	Margin of Safety
MPN	Most Probable Number
MW	Megawatt
n	Number of samples or members of a sample set
N	Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSDZ	Near Stream Disturbance Zone
NTP	Natural Thermal Potential (Natural Condition Criteria, OAR 340-041)
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OGIC	Oregon Geographic Information Center
OWRD	Oregon Department of Water Resources
P	Phosphorus

POD	Point of Diversion
POMI	Point of Maximum Impact
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RC	Reserve Capacity
SWCD	Soil and Water Conservation District
SRP	Soluble Reactive Phosphorus
TIR	Thermal Infrared Radiometry(synonym for Forward Looking Infrared Radiometry)
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USFW	United States Fish and Wildlife Service
USGS	United States Geological Survey
u/s	Upstream
W	Watt
WDFW	Washington Department of Fish and Wildlife
WLA	Wasteload Allocation
WWTP	Waste Water Treatment Plant
WQ	Water Quality
WQMP	Water Quality Management Plan
WRIS	Water Rights Information System

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Appendix B: Description of Selected Terms

Highlighted terms are defined in rule and the reader should refer to the text of the rule.

Anthropogenic	Generated or caused by humans or activities related to humans.
303(d) Listing	Listing of a water body in accordance with Section 303(d) of the Clean Water Act.
Counts per deciliter	Concentration units typically associated with bacteria analysis, where 'counts' are the number of organisms (colonies). A deciliter is one-tenth of a liter.
Criteria, Biologically Based Criteria	Typically used herein in the context of water quality standards. The 'criteria' is the numeric or narrative target of the standard, designed to protect beneficial uses. Biologically based criteria are derived from studies of the requirements of aquatic organisms, often fish. Other criteria, such as the *protecting cold water criteria*, may target other provisions of water quality standards such as the anti-degradation policy.
Designated Management Agency	Organization responsible for Implementation Planning designed to attain TMDL load allocations and surrogates. OAR 340-042-0025: Federal, state or local government agency that has legal authority over a sector or source contributing pollutants, and is identified as such by the DEQ in a TMDL.
Diel	The 24-hour cycle of temperature change associated with day and night.
Epilimnion	The top-most layer in a thermally stratified lake. It is warmer and typically has a higher pH and dissolved oxygen concentration than the hypolimnion.
Human Use Allowance	Potentially allowable temperature difference in excess of applicable water quality critieria (OAR 340-041-0028 (12)(b))
Hydrologic Unit Code	A nesting classification of watersheds.
Hypolimnion	The bottom and most dense layer of water in a thermally-stratified lake.
Load Allocation	Refer to beginning of **Section 1.3h**, **Part 1**
Loading Capacity	Refer to beginning of **Section 1.3d**, **Part 1**
Log mean	The nth root of the product of n samples. The log mean of a data set can be calculated by taking the arithmetic mean of the logarithms of each value. Also called geometric mean.
Nonpoint Source	Diffuse landscapes source of pollution
Natural Thermal Potential	Natural Condition Criteria, OAR 340-041. The determination of the thermal profile of a water body using best available methods of analysis and the best available information on the site-potential riparian vegetation, stream geomorphology, stream flows, and other measures to reflect natural conditions.
Near Stream Disturbance Zone	The corridor between shade-producing near-stream vegetation or other features related to channel morphology and vegetation.

Point of Maximum Impact	Refer to (OAR 340-041-0028 (12)(b))
Point Source	Localized human-made source of pollution, conveyed to water body via human made conveyance.
Reserve Capacity	Refer to beginning of **Section 1.3k**, **Part 1**
Sinuosity	The curving path of a stream, measured as valley length divided by stream length.
Subbasin	4th field of the Hydrologic Unit Code classification of watersheds.
Surrogate	An alternative target to a load allocation, a measure to achieve a load allocation, expressed typically in units or measures other than mass per time.
Total Maximum Daily Load	Described in Document Summary page.
Thermistor	A small electronic device used to record stream temperature at one location for a specified time interval.
Wasteload Allocation	Refer to beginning of **Section 1.3g**, **Part 1**

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Appendix C: Monitoring Related to Temperature, Bacteria and pH

During the summers of 2000 and 2001, DEQ conducted TMDL monitoring in the sub-basin and gathered available pH data from other organizations: USGS, USACE and the City of Heppner. Subsequently, more data have been collected by the USACE. In general, the available data collection events with monitoring parameters relevant to the identified pH, temperature and bacteria issues, are as follows:

USGS – pH: 1964-1986; Willow Creek at Lexington & Heppner, Balm Fork near mouth
DEQ TMDL monitoring – including August continuous temperature monitoring, flow and morphology: July-September of 2000; ten sites longitudinally distributed along Willow
DEQ TMDL monitoring – including 3-day data-logger pH/temperature/dissolved oxygen, field measurements and laboratory water quality samples: July/August, 2001; Willow Creek at Ione, Lexington, Heppner, highway crossing ¼ mile above reservoir and in the Reservoir
DEQ Mixing Zone Study – pH, temperature, nutrients: 1999; Heppner waste water treatment plant outfall
USACE – bacteria, DO, temperature, pH: 1984-1996 Willow Creek Reservoir limnological study (referenced in **Appendix E**) and 1997-2005 monitoring in, above and below Reservoir
Volunteer monitoring – *E. Coli*: 1996-1997; Balm Fork
City of Heppner monthly waste water treatment monitoring reports – pH temperature and other data are compiled electronically for TMDL assessment, 2000-2005. Hard copy data extends much earlier.

Data quality for DEQ and voluntary monitoring by the area resident met the Department's rigorous quality assurance and quality control protocols. Data from other organizations appears consistent and well documented. Sampling and analysis plans (Quality Assurance Project Plans) for DEQ's monitoring are on file with the DEQ laboratory. All data used in this document are on file electronically in the Pendleton DEQ Regional Office. DEQ monitoring locations are portrayed in **Figure C-1** and **Table C-1.** Additional site locations are shown in **Figures 1-3 (Section 1.2)** and **C-2 (this appendix)**.

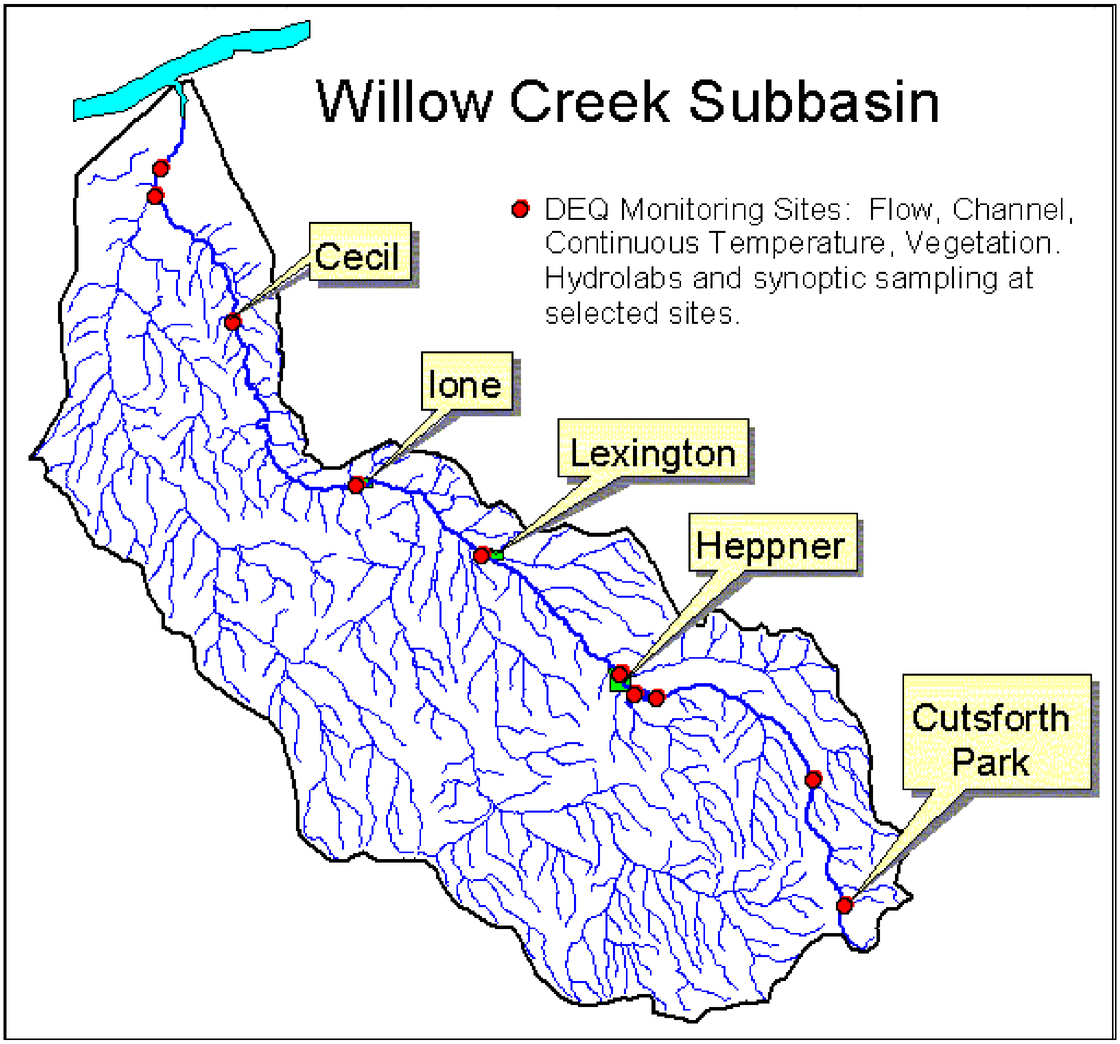

Figure C-1. *Temperature TMDL specific DEQ monitoring locations on Willow Creek (year 2000 temperature data loggers, channel morphology, flow and vegetation assessment)*

Table C-1. *All DEQ monitoring sites during 2000 and 2001*

Site #	Stream	Site Description	River Mile	Latitude	Longitude
0.5	Willow Ck	Base of Highway grade	5.0	45.74315	-120.02322
1	Willow Ck	200 yards below northernmost hwy 74 brdg	5.5	45.73626	-120.02887
2	Willow Ck	Bridge (d/s side) below 8 Mile Creek	8.0	45.71310	-120.03880
3	Willow Ck	Bridge (d/s side) at Cecil	17.8	45.61930	-119.95840
4	Willow Ck	Bridge (d/s side) by Ione High School	34.1	45.49890	-119.82980
5	Willow Ck	Lexington F-St. bridge (d/s side)	44.0	45.44720	-119.69920
6	WWTP effluent	Heppner WWTP outfall	54.4	45.36930	-119.57000
7	Willow Ck	Heppner WWTP, golf course bridge above outfall	54.5	45.36560	-119.56470
8	Willow Ck	50 meter d/s Heppner City Park at Church St	55.3	45.35800	-119.55310
9	Willow Ck	NW Gale St. bridge (d/s side)	55.1	45.35930	-119.55510
10	Willow Ck Reservoir	Boat dock, 4th metal column from shore	55.5	45.34380	-119.53920
11	Balm Fork	Gage site, Balm Fk road crossing	0.5	45.33166	-119.53994
11.5	Balm Fork	Bridge crossing, end of pavement on County road	6.0	45.27877	-119.48109
12	Willow Ck	1/4 mile u/s reservoir, directly beneath hwy bridge	55.9	45.34050	-119.51730
13	Willow Ck	Rd	69.3	45.18630	-119.32340
14	Willow Ck	1/4 mile u/s Cutsforth Park	77.3	45.27870	-119.35380

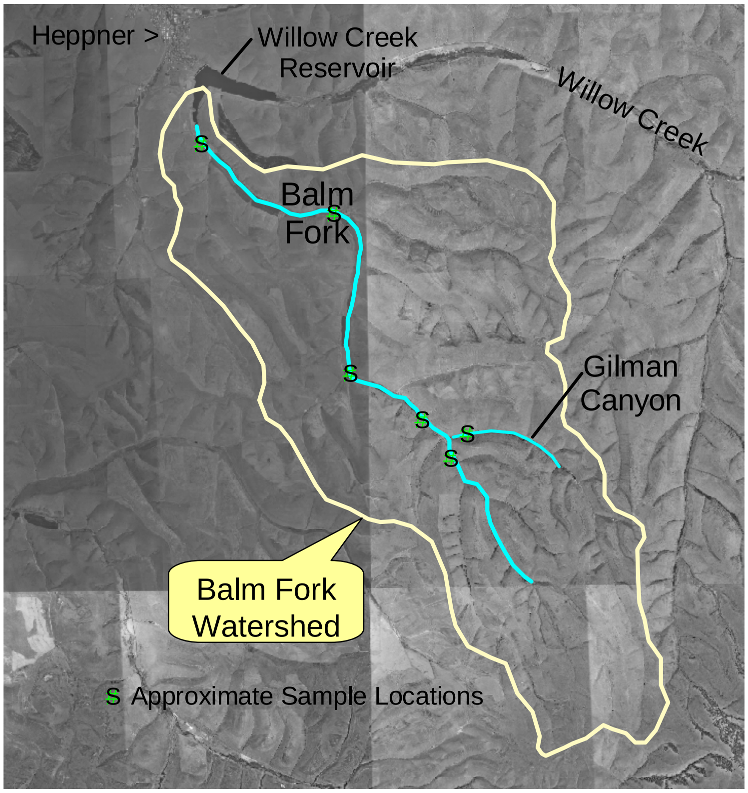

Figure C-2. *Volunteer monitoring locations in the Balm Fork watershed (1996 and 1997, E. coli monitoring)*

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Appendix D: Stream Temperature Assessment

Attached or as separate volume (separate digital file)

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Appendix E: Stream pH Assessment

This pH assessment in the Willow Creek Subbasin addresses the Willow Creek mainstem. This monitoring and assessment evaluates the Willow Creek 303(d) listing (**Table E-1**) and makes recommendations regarding Total Maximum Daily Load development. The TMDL stemming from this assessment is reported in **Section 1.4** of the main document.

E1. Indication of Water Quality Impairment

Willow Creek was first identified as *water quality limited* in 1998, as the Department assessed area data over recent decades. Streams are classified *water quality limited* when they do not meet water quality standards, even with permitted "point" sources implementing standard treatment technology. The Willow Creek pH 303(d) listing (**Table E-1**) is based on data collected by the US Geological Survey (USGS) just below Willow Creek Reservoir near a USGS gage site (#0345). The listing is for summer, based on six out of twelve samples exceeding the pH standard during the summer of 1986. The maximum pH measurement was 9.2 (all pH measurements associated with this appendix are in standard pH units). This listing triggers the TMDL evaluation, in accordance with a state-wide prioritization for water quality prepared at the sub-basin scale. The listing addresses Willow Creek from its mouth to just below the Willow Creek Reservoir. The Reservoir is immediately upstream from the city of Heppner, Oregon. As stated in **Section 1.2**, the Willow Creek Reservoir dam was built during 1980-1983.

Table E-1. *Willow Creek Subbasin pH 303(d) listing. The listed segment (river mile 0 to 51.7) is from the mouth to the Willow Creek Reservoir.*

Record ID	Waterbody Name	River Mile	Parameter	Season	List Date
5260	Willow Creek	0 to 51.7	pH	Summer	1998

E2. TMDL and Inter-Organizational Monitoring

The TMDL-specific monitoring for Willow Creek Subbasin was implemented in 2000 and 2001 by DEQ. Several other organizations have collected data over the years that add to this. The pH TMDL relevant dataset spans from 1972-2005 and was collected by: The USACE, USGS, DEQ, City of Heppner and the Port of Morrow. Monitoring events and quality assurance are discussed in **Appendix C**. The Willow Creek Reservoir USACE limnological study of Larson (1997) reports pH and other water quality data for various years. Not all of that data was available for this analysis, however data summaries and evaluation from the limnological study are incorporated into this TMDL evaluation where relevant. The Willow Creek Reservoir limnological study addressed water quality monitoring conducted from 1984-1996. Monitoring objectives included acquisition of post-impoundment base-line water quality data, supporting evaluation of cause-effect relationships between limnological processes (e.g., hypolimnetic anoxia and chemical reduction), and identification of methods to minimize or curtail water-quality problems resulting from adverse Reservoir conditions. Such problems had been predicted by Funk (1973) during a pre-impoundment water quality study of the Reservoir. Funk stated: "I believe we can expect blue-green (algae) blooms almost every year." He expected that through time, decomposition of accumulated algal biomass would deplete hypolimnetic dissolved oxygen, leading to the formation of compounds such as hydrogen-sulfide and ammonia.

A large proportion of the inter-organizational pH data was collected at or near the Willow Creek Reservoir and Heppner area. The available pH data from this area is summarized in **Figure E-1**. Maps and overview of the Willow Creek Subbasin are provided in **Section 1-2** as are the locations of key monitoring sites (**Figure 1.2-3**). All DEQ monitoring locations are identified in **Appendix C**.

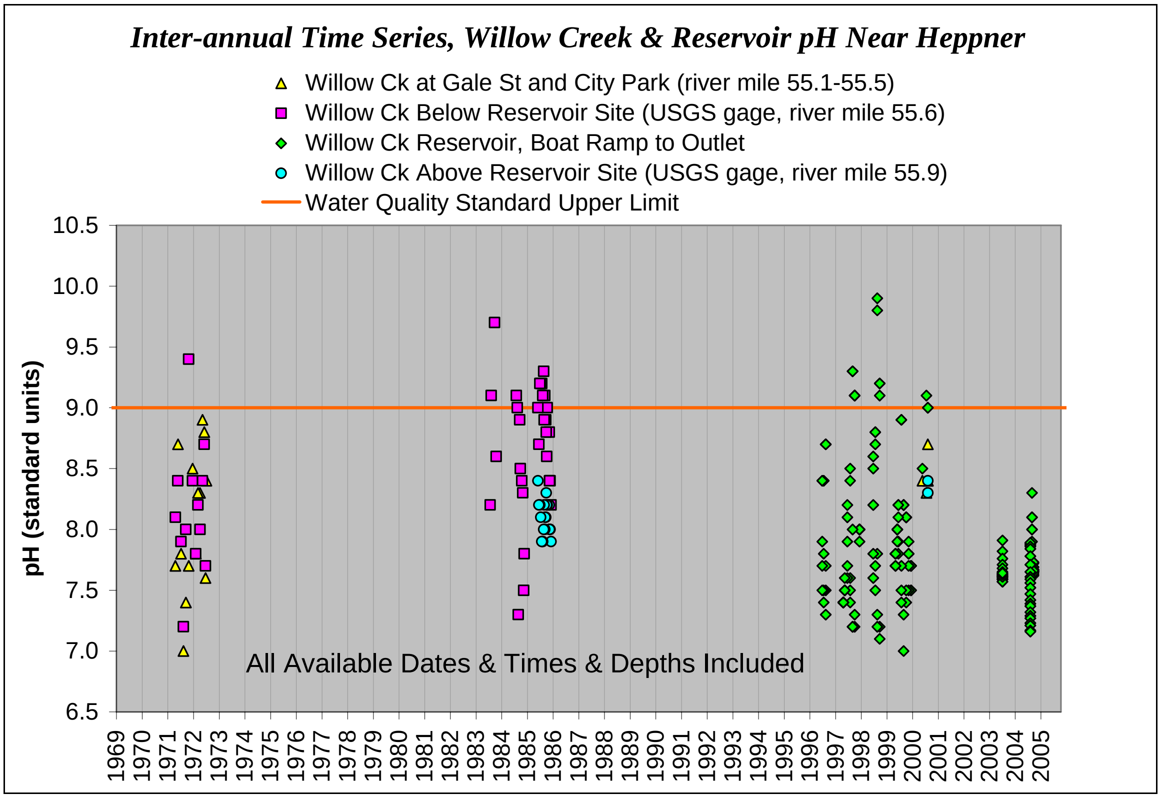


Figure E-1. *Year round pH measurements from 1972-2005, near Heppner. The Reservoir data was collected at various depths, from mid-Reservoir to near the outlet.*

E3. Timing, Location and Cause

Background

The following is a general discussion of pH and the processes by which pH varies in surface water:

> *pH is an inverse measure of hydrogen ion concentration. Stream pH levels usually fall between 6.5 and 8.5, although wide variations can occur because of local watershed geology. Streams that drain soils with high mineral content usually are alkaline, whereas streams that drain coniferous forests usually are acidic (Allan 1995). Most rainwater has a pH of 5.6 to 5.8. This acidity is due to the presence of carbonic acid (H_2CO_3). The latter is formed from by the interaction of water (H_2O) with atmospheric carbon dioxide (CO_2).*

Normally these acids are neutralized as rainwater passes through the soil. However, in watersheds with heavy rainfall, little buffering capacity and acidic soils, surface water pH may be largely reflective of the rainwater pH values. Human factors including industrial runoff and acid rain may also impact surface water pH within a watershed. Most aquatic organisms, including benthic macroinvertebrates, salmonids and amphibians, are sensitive to pH changes and prefer a pH in the range of 6.0 to 9.0 (EPA Quality Criteria for Water, 1986).

As water enters a creek or river and flows downstream, pH can be substantially influenced by biological activity, particularly in the summer. With increasing sunlight from morning to afternoon, a typical stream experiences increasing oxygenation and decreased dissolved CO_2 and hydrogen ion concentrations, due to algal photosynthesis. The opposite trend is manifest at night, with algal respiration and die-off consuming oxygen and liberating CO_2 and hydrogen ions. Accordingly, in a warm summer afternoon pH and dissolved oxygen concentrations are at a peak and they are minimal just before dawn. A distinctive diel pattern (daily cycling) results, and its range typically increases downstream with increasing sunlight, warmth and nutrient availability.

Lakes and impoundments, behave similarly in their upper levels or if shallow. Provided that sufficient nutrients are available, sunlight and heat drive the diel cycle. Sunlight attenuates in the water column, particularly if clarity is low – little photosynthesis takes place at depths of a few meters or more. In summer afternoons pH increases upward in the water column as does its diel fluctuation. Further information is available in DEQ's 1992-1994 Water Quality Standards Review (1995).

Exceedance of Standard

The inter-organizational pH dataset includes and is more extensive than the data reviewed for the 1998-2004 303(d) lists. **Figure E-1** confirms that the pH standard has been frequently exceeded. **Figure E-2** portrays the same data plotted by month. In these and subsequent figures, the upper pH criterion limit of 9.0 is shown. In accordance with OAR 340-041-0315, Willow Creek "pH values may not fall outside the following range: all Basin streams (other than the mainstem Columbia River): 6.5-9.0" and "when greater than 25% of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department will determine whether the values higher than 8.7 are natural or anthropogenic in origin." The proportion of measurements exceeding 8.7 is evaluated as follows: The relatively high pH measurements triggering the 303(d) listing occur just below the Reservoir (discussed later in this Appendix). With regard to the Reservoir, the ambient site is the Reservoir inflow. The 75th percentile of June-September inflow data, for Willow Creek and Balm Fork at USGS gages just above the Reservoir, are 8.2 (n=14) and 8.4 (n=17), respectively. Hence, less than 25 percent of ambient measurements are greater than 8.7.

The monthly and inter-annual patterns (**Figures E-1** and **E-2**) indicate that, as is normal, elevated pH is a warm season issue. As indicated in **Figure E-2**, the critical season when pH has exceeded the water quality standard is June through September. The decreased Reservoir pH in 2004 and 2005 (**Figure E-1**) is resultant from changes in Reservoir operations as will be discussed in following sections of this appendix. For the 2000-2001 and prior monitoring, June through September 90th percentile exceedances of the upper pH criteria are shown in the longitudinal distribution of **Figure E-3**. The longitudinal pattern affirms that not listing (303(d)) above the reservoir is appropriate.

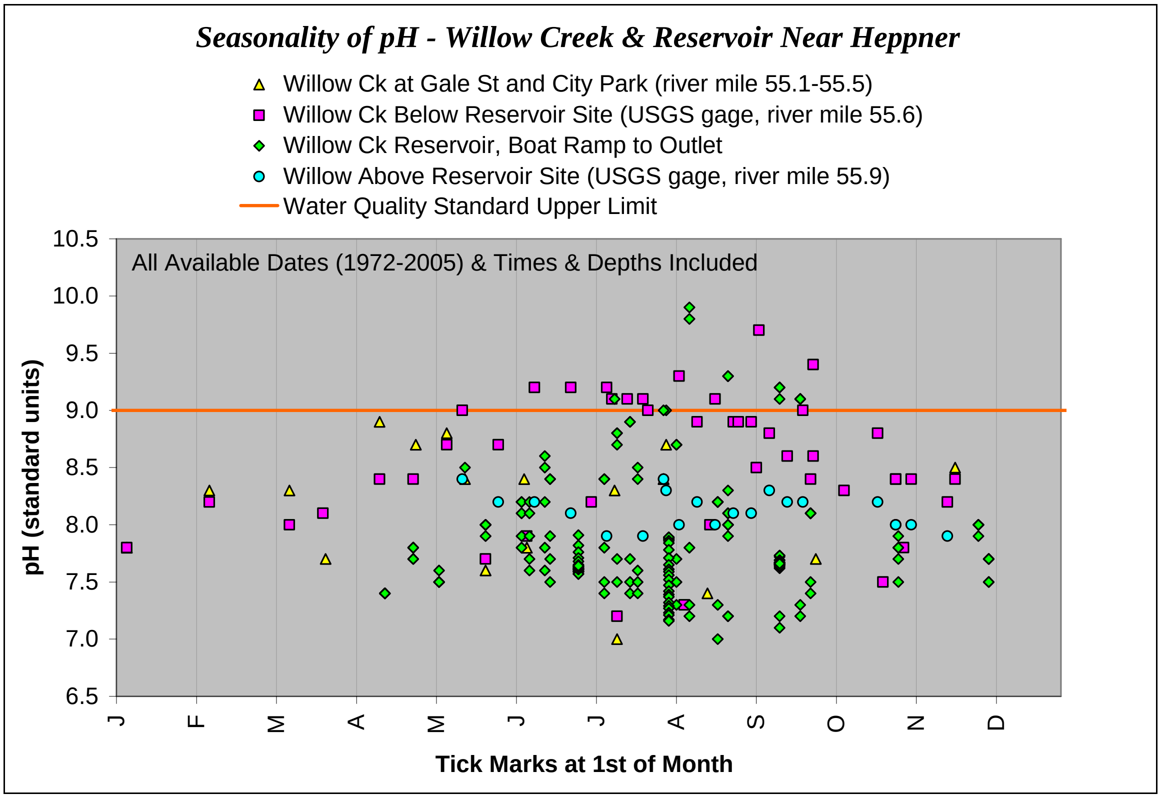


Figure E-2. *Monthly graph of pH from 1972-2005, in the Heppner vicinity*

Box plots, such as **Figure E-3** are used in this text. Box Plots are used to illustrate the distribution of samples through time or among places, based on percentiles. The percentile indicates the percentage of sample values less than the value at that point in the distribution. In a typical box plot the upper and lower edges of the box are the 75th and 25th percentiles. For the purposes of this pH assessment Appendix the 90th and 10th percentiles are used. Within the box, the median is also shown. By definition, the median is the 50th percentile, with 50% of values lower and 50% of values higher than the median. The 90the percentile is the value exceeding the values of 90 percent of the samples, and so on.

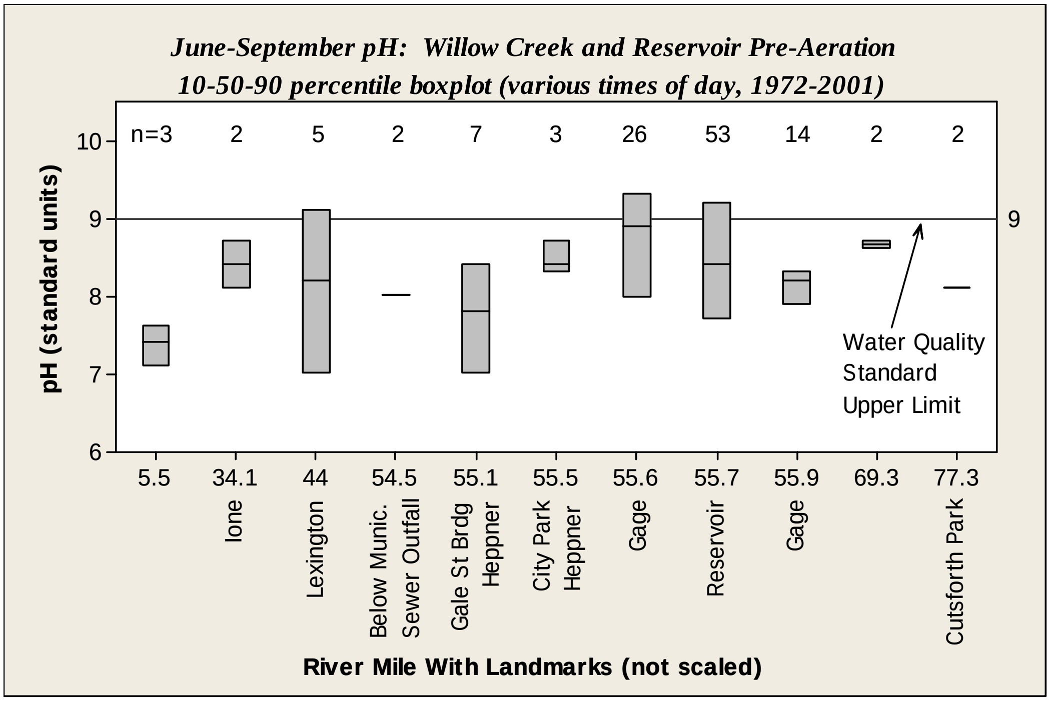


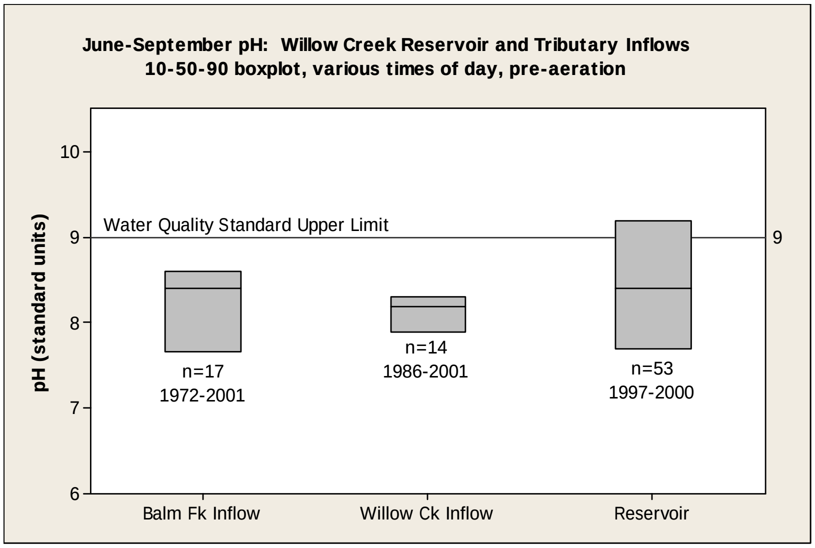
Figure E-3. *Longitudinal distribution of June through September pH in Willow Creek during the years of data collection prior to Reservoir aeration. Reservoir data represents a variety of depths.*

Reservoir Influence

As mentioned in **Section 1.2**, an aeration system was installed in Willow Creek Reservoir beginning in 2004. The aerators were operated June 19 through November 22 in 2004 and March 15 through October 27 in 2005. The pH patterns in the Reservoir, and below in Willow Creek, are influenced by this program. As such, it makes sense to look at the data in two phases: before and after aeration. All available pre-aeration warm season pH data (1972-2001) are summarized in the longitudinal profile shown in **Figure E-3**. Prior to Reservoir aeration, a significant number of Willow Creek pH measurements exceeded the pH standard at Lexington and at Heppner immediately below the Reservoir. In the Heppner area, the elevated pH was associated with Reservoir conditions, consistent with the limnological study of Larson (1997). **Figure E-3** and pH ranges reported by Larson (**Table E-2**) indicate a significant increase in Willow Creek pH due to the presence of the Reservoir. Unlike the pre-aeration Reservoir, inflows are well within the pH water quality standard. Note that the Reservoir data summarized in **Figure E-3** is for a range of depths and therefore masks the large proportion of high pH measurements in the epilimnion. Reservoir stratification is discussed briefly in **Section 1.2** and in greater detail subsequently in this section.

Table E-2. *Pre-aeration tabulated ranges of pH (with number of samples) from Larson (1997, tables 110-112) and box plot of tributary inflow pH*

Date	Willow Creek inflow to Reservoir	Balm Fork Inflow to Reservoir	Willow Creek outflow from Reservoir
May 14-Nov 18, 1986	7.9-8.4, n=18	8.0-8.8, n=18	8.2-9.3, n=18
Apr 30-Dec 9, 1996	8.1-8.5, n=8	7.9-8.8, n=8	8.1-9.1, n=17



It is notable in **Figure E-3** that median pH levels in the Heppner vicinity appear to decrease rapidly downstream from the Reservoir in the Heppner vicinity. Later in this section the downstream exceedance of pH criteria near Lexington is discussed.

Prior to aeration, Willow Creek Reservoir manifested strong thermal and compositional depth-gradients in the warm season, as indicated by measurements of pH, temperature, dissolved oxygen and other constituents at varying depths. June-September afternoon pH decreased dramatically with depth, as shown in **Figure E-4**. The high pH at relatively shallow outflow levels caused exceedance of the pH standard downstream. This is because the most of the Reservoir discharge was from a relatively shallow level. As discussed in **Section 1.2**, Reservoir release mechanisms allow for varying depths of withdrawal.

During aeration, compressed air rising from the lake floor generates a vertical mixing action within the reservoir. During the warm season, mixing leads to a less stratified and lower overall pH pattern, as the large volume of low pH water at depth mixes with relatively thin photosynthetic upper layer. **Figure E-5** illustrates this pH pattern. With the aeration-mixing, Reservoir pH now meets the Willow Creek pH standard even at relatively shallow depths. This conclusion is relatively robust because the pre-aeration depth profile consists largely of morning data while much of the 2004-2005 data collection occurred in the afternoon. In other words, the 2004-2005 data readily meets the pH water quality standard for Willow Creek even though measured at the time when exceedance is most likely.

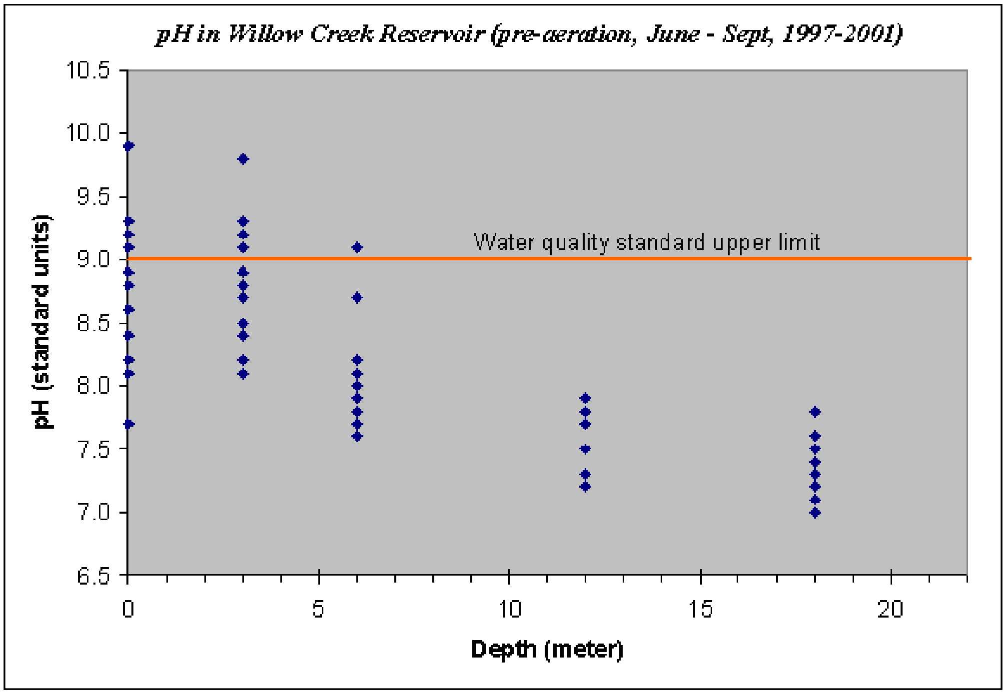


Figure E-4. *Graph of pre-aeration pH measurements at varying depths in relatively near proximity to the reservoir outlet. Data from USACE. About half the data was reported with collection time of day. Data of known collection time were acquired from 9:15 a.m. to 1:44 p.m. Five of these were collected after noon.*

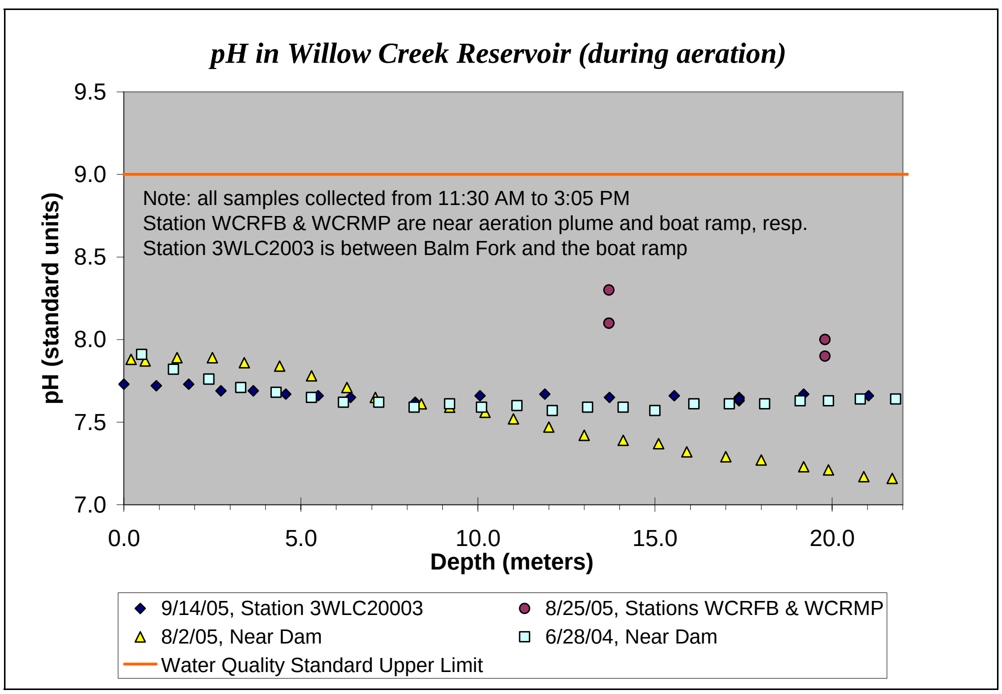


Figure E-5. *Graph of pH measurements during aeration at varying depths in relatively near proximity to the reservoir outlet. Data from USACE.*

Due to the homogenization of the reservoir and the relatively close proximity of sampling to the release structure, the in-reservoir data shown in **Figure E-5** is also representative of Willow Creek below the reservoir regardless of withdrawal depth. Whereas dissolved oxygen increases dramatically due to aeration in the cascading outfall of the Reservoir, ph is relatively stable. Post 2001 Willow Creek monitoring above and below the reservoir has not been implemented, but for the reasons just described this is not viewed as problematic. The during-aeration reservoir pH data, expected to be similar to Willow Creek in Heppner, is summarized in **Figure E-6**.

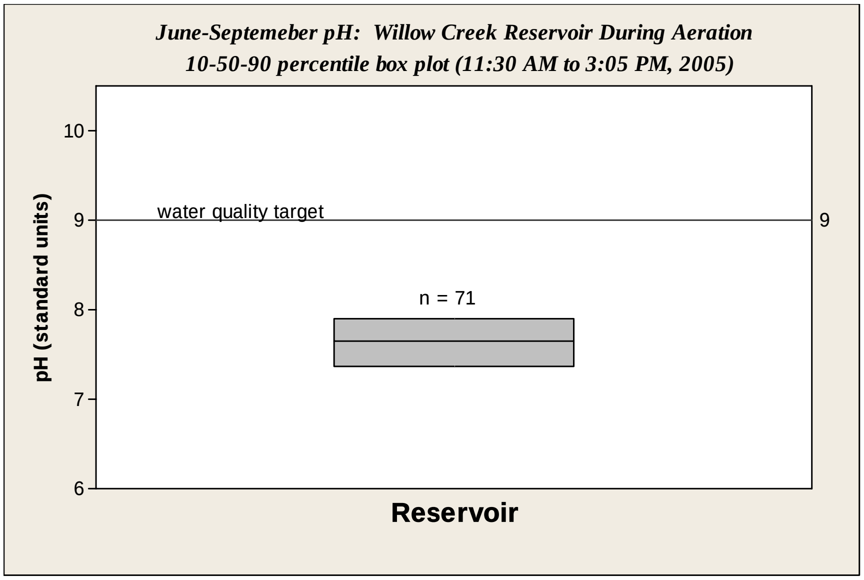


Figure E-6. *June through September 2004-2005 pH data (same data as **Figure E-5**, during aeration) illustrated as a box plot*

Below the Heppner USGS Gage Site

The 303(d) pH listing (**Table E-1**) is for the length of Willow Creek below the Reservoir. This is based on a single site, the USGS gage site at Heppner, addressed in preceding sections of this Appendix. While pH exceedances at this site can be eliminated by Reservoir operations, this improvement is not expected to carry far downstream, as pH re-equilibrates to stream conditions and flow decreases downstream. Because of this and relatively high pH levels found at Lexington during TMDL monitoring, it is of value to discuss pH levels and controls below the Heppner gage.

<u>Flow</u>. Even with the recent large increases in summer Reservoir discharge (**Section 1.2**), Willow Creek surface flow does not reach the Columbia River year round. At some point, typically between Lexington and Ione, irrigation withdrawals, bed losses and/or evaporation entirely attenuate surface flow. Between this point and river mile 5 (kilometer 8) much of Willow Creek has a dry stream bed throughout parts of July, August and September (also refer to **temperature TMDL** and **Section 1.2** for discussion of flow patterns). As part of the TMDL monitoring, instream flow was measured at Lexington, with the following results:

- July 31, 2000: 3.6 cubic feet per second (0.10 cubic meters/second)
- September 8, 2000: no surface flow
- July 5, 2001: 1.9 cubic feet per second (0.05cubic meters/second)
- July 31, 2001: 0.8 cubic feet per second (0.02cubic meters/second)

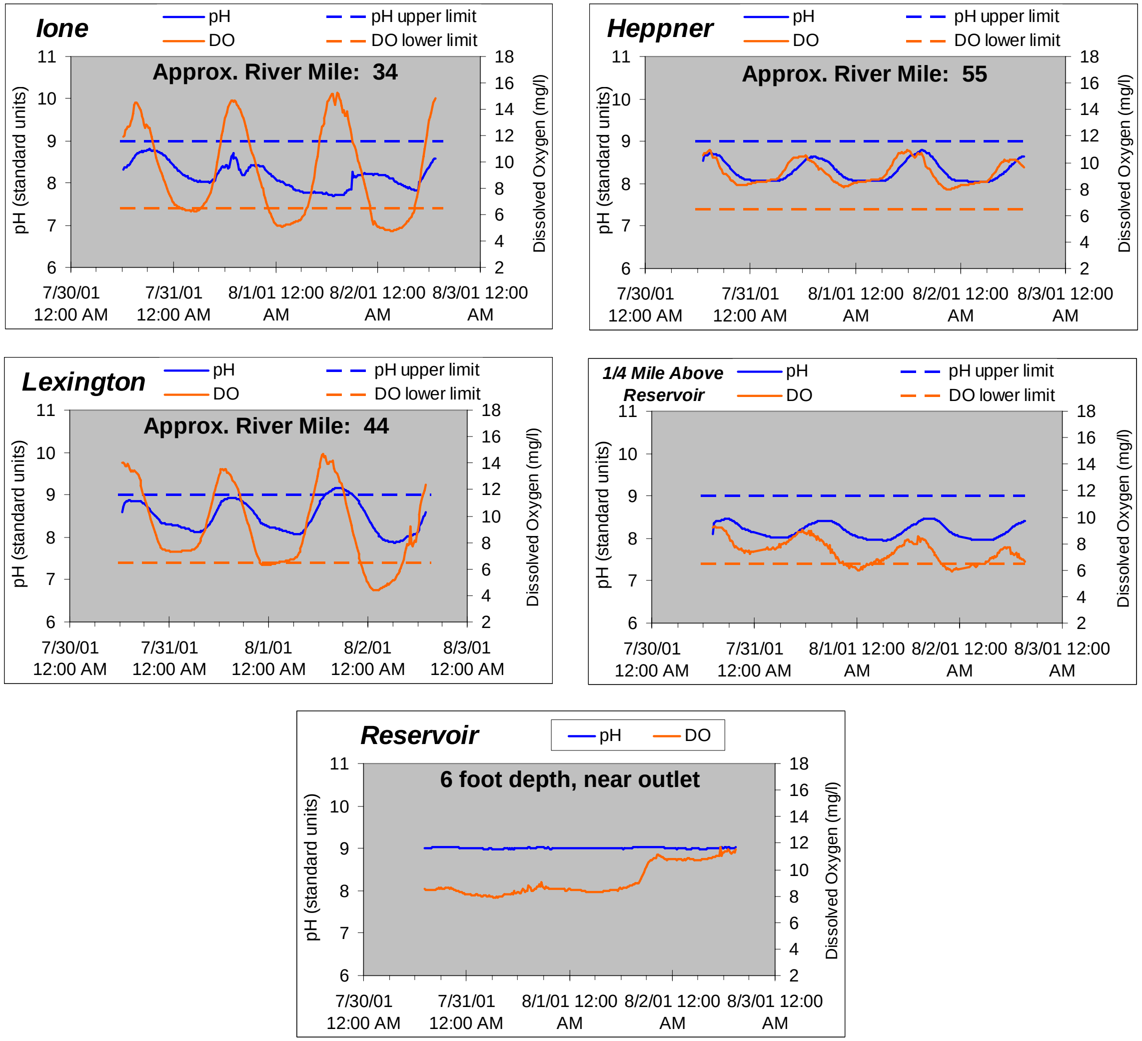
Below Ione a dry streambed was observed during this monitoring at various roadside overlooks and the lowermost Hwy 74 bridge at river mile 5.5 (kilometer 9). Discussions with community residents indicate that continuous flow extends further downstream than usual with the recently increased Reservoir outflow, however not by a great distance.

Below the Reservoir, during the time of lowest instream water levels, measurable flow inputs to Willow Creek include Shobe Creek, Hinton Creek and the two individual NPDES sources. Though large in watershed area, Rhea Creek and Eightmile Creek had dry streambeds at their mouths in this time frame. Late July tributary flow measurements in 2000 and 2001 were 0.004 CFS (0.0001 CMS) in Shobe Creek and 0.5-2 CFS (0.014-0.06 CMS) in Hinton Creek. As discussed in **Section 1.2**, high range flows for the Heppner treatment plant and the Oregon Co-Gen facility effluents are 0.39 CFS (0.01CMS) and 0.19-2.6 CFS (0.005-0.07CMS). The Port of Morrow evaluation of the rapid infiltration basin states that flows of 0.22 CFS (0.006CMS) are normal upper-end flows, rather than the 2.6 CFS (0.07CMS) representing maximum potential flow. During the warm season, much of the Heppner treatment plant effluent is diverted for re-use and is not discharged directly to Willow Creek.

pH. As flows diminish downstream of Heppner, conditions favor wide diel pH swings in warm months. Decreased flow lessens assimilative capacity for solar energy, resulting in increased temperature. Additionally, minimal riparian shade and a wide stream channel result in a large degree of solar exposure (see temperature TMDL and appendix), also causing stream heating. High temperature and light exposure can lead to increased algal growth, leading to high afternoon pH as discussed previously. **Figure E-3** shows summer 2000 exceedance of pH criteria in Willow Creek at Lexington [maximum pH of 9.1 in 6 samples, river mile 44 (kilometer 68)] and a similar exceedance was measured at the same location in 2001 with instream continuous data recorders (maximum pH of 9.16 in 3 days, **Figure E-7**). The pH of flow inputs to Willow Creek are considered as follows, in terms of direct mixing pH influence: Shobe discharge is so slight it would not significantly influence Willow Creek. Though data is lacking for Hinton Creek, it apparently does not cause an increase in Willow Creek pH (**Figure E-3**, Hinton confluences between the City Park and the Gale Street Bridge). The Heppner treatment plant effluent decreases the pH in Willow Creek (compare **Figures E-3** and **E-8**). The Oregon Co-Gen Generating Plant effluent has higher pH than Willow Creek (again refer to **Figures E-3** and **E-8**) but is still within the pH standard. Data is limited for the Generating plant, which is not currently operating. Available Port of Morrow data and projected impacts for the Generating Plant are listed in **Tables 1.2-5** and **1.2-6** of **Section 1.2** (**main document**), including mixing calculation results and ground water entering Willow Creek from the rapid infiltration basin. Based on this information, pH levels in the tributaries are not problematic (though this is under review and there is an apparent error in the Generating Plant **Table 1.2-7** – linear mixing of pH seems to have been assumed – further evaluation has been requested of the facility). Existing pH limits in the NPDES permits (pH of 6.5-9.0) should sufficiently address pH levels in Willow Creek associated with effluent mixing. However, the Oregon Co-Gen facility should exercise particular care as it has the potential for relatively high pH and effluent discharge rates.

Dissolved Oxygen. Though dissolved oxygen is not the focus of this TMDL and Willow Creek Subbasin has no 303(d) listings for dissolved oxygen, it was included in TMDL monitoring as a related parameter. During July 30 through August 3 of 2001, multi-probe data recorders measured oxygen along with pH (**Figure E-7**), temperature and conductivity. At Ione and Lexington wide diel concentration fluctuations were observed, with one-day minimums of 4.8 and 4.4 mg/l dissolved oxygen. The target single-sample minimum in lower-mid Willow Creek is 6.5 mg/l. As described previously low dissolved oxygen concentrations are associated with high algal mass. Reductions in light, heat and nutrients address both dissolved oxygen and pH. The Heppner Treatment Plant NPDES permit limits BOD_5 to 30-45 mg/l.

Figure E-7. *Willow Creek dissolved oxygen and pH data from summer 2001 continuous monitoring implemented by DEQ*



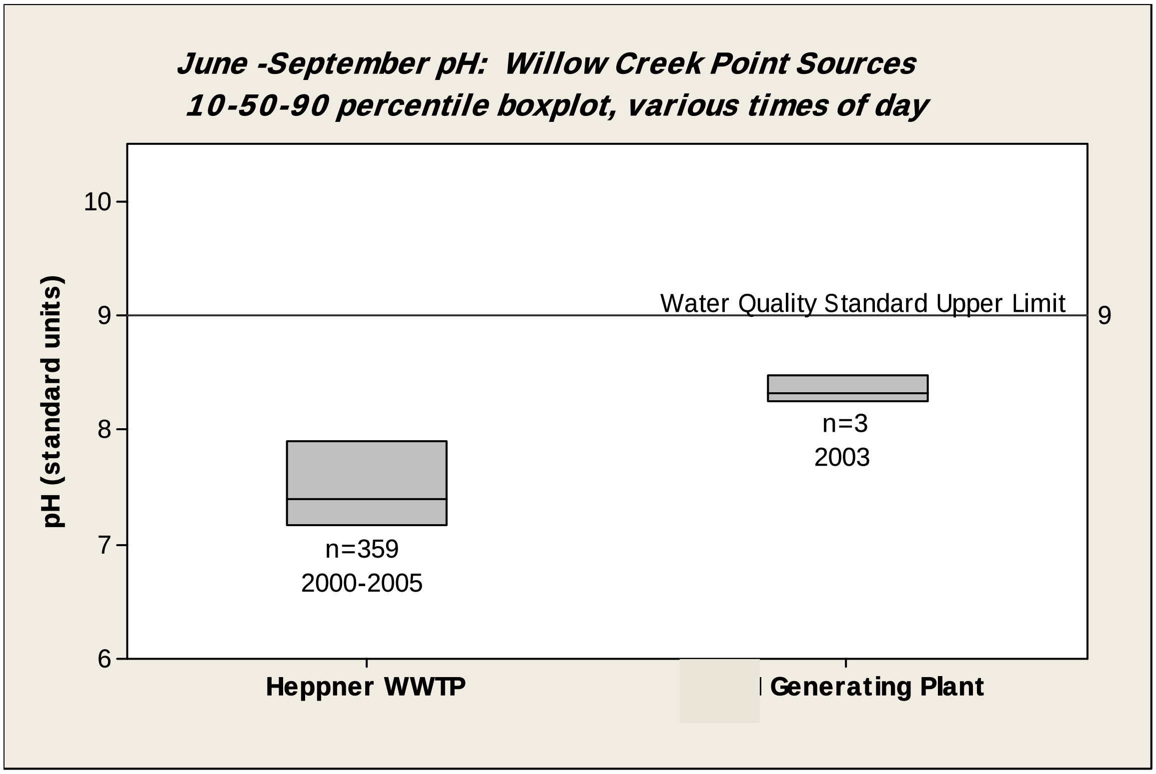


Figure E-8. *Box plot of pH measurements of the City of Heppner waste water treatment plant and Oregon Co-Gen Generating Plant discharges to Willow Creek*

Nutrients

Though tributaries and point sources appear not to cause pH excesses as they mix into Willow Creek, nutrient loading should be considered due to potential downstream effects. At this point a focus on ***point sources*** is appropriate because of the Department's responsibilities concerning permitted discharges, and because of the fact that nonpoint sources of nutrient have not been studied in the Willow Creek Basin. Ambient nutrient concentrations (**Table E-3**) are relatively normal compared to the neighboring Umatilla River, where nutrients were not considered to be at levels of concern, and were not the cause of the pH standard exceedances found there.

As described previously, nutrients are involved in diel fluctuations of pH and dissolved oxygen due to their role in sustaining algae. Since not all nitrogen and phosphorus in a stream is available for algal growth, any nutrient limits should be provided in terms of the reactive inorganic forms. For nitrogen this is the dissolved inorganic nitrogen (DIN), which includes ammonia, nitrite and nitrate. For phosphorus it is the dissolved orthophosphate (equivalent to soluble reactive phosphorus or SRP). The limiting nutrient can vary along the length of the stream. Longitudinal patterns of nutrients are shown in **Figures E-9** and **E-10**. It is notable that, based on limited data, that generally increasing nutrient concentrations are present in Willow Creek due to the Reservoir and below the City of Heppner Treatment plant. Light and heat, as discussed previously, can also be limiting factors for algal activity relating to elevated afternoon pH.

Table E-3. *Nutrient monitoring data for Willow Creek, Balm Fork , Willow Creek Reservoir and City of Heppner Waste Water Treatment Plant. Data are from DEQ, USACE, City of Heppner, USGS.*

Below-Reservoir Site Descriptions	Date	NO2+NO3 (mg/l as N)	Ammonia (mg/l as N)	Ortho-P (mg/l as P)	DIN (mg/l as N)	DIN/Ortho-P
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	11/10/1975	0.64	0.05	0.14	0.69	4.93
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	7/9/1975	0.30	0.15	0.27	0.45	1.67
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	5/28/1975	0.32	0.16	0.20	0.48	2.40
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	11/11/1974	0.30	0.06	0.09	0.36	4.00
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	7/31/1974	0.57	0.03	0.05	0.60	12.00
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	5/8/1974	0.64	0.08	0.13	0.72	5.54
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	9/26/1973	0.02	0.12	0.05	0.14	2.80
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	6/13/1973	1.65	0.07	0.36	1.72	4.78
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	2/11/1973	0.74	0.08	0.96	0.82	0.85
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	7/8/1968	0.26	0.76	0.08	1.02	12.75
Willow Creek @ Hwy 74 lowermost bridge, river mile 5.5	2/11/1968	2.86	0.28	0.14	3.14	22.43
Willow Cr. @ bridge near Ione High School, river mile 34	8/1/2001	0.38	0.09	0.04	0.47	12.70
Willow Cr. @ bridge near Ione High School, river mile 34	7/31/2001	0.55	0.05	0.05	0.60	11.44
Willow Cr. @ F-Street in Lexington, river mile 44	7/31/2001	0.0025	0.04	0.08	0.04	0.52
Willow Cr. @ F-Street in Lexington, river mile 44	8/1/2001	0.01	0.04	0.09	0.05	0.50
Willow Ck 200 Ft Below WWTP Mixing Zone, river mile 54.5	10/19/1999	0.26	0.13	0.09	0.39	4.25
Willow Ck 200 Ft Below WWTP Mixing Zone, river mile 54.5	2/11/1968	1.34	0.32	1.30	1.66	1.28
Willow Ck 150 Ft Below WWTP Mixing Zone, river mile 54.5	10/19/1999	0.26	0.12	0.07	0.38	5.32
Willow Ck 100 Ft Below WWTP Mixing Zone, river mile 54.5	10/19/1999	0.36	0.19	0.09	0.55	5.85
Willow Cr. @ bridge u/s of Heppner WWTP outfall, river mile 54.5	7/31/2001	0.79	0.07	0.14	0.86	5.99
Willow Cr. @ bridge u/s of Heppner WWTP outfall, river mile 54.5	8/9/2001	0.40	0.03	0.07	0.43	5.99
Willow Cr. @ bridge u/s of Heppner WWTP outfall, river mile 54.5	10/19/1999	0.09	0.03	0.03	0.12	5.99
Willow Cr. @ NW Gale Str. Bridge in Heppner	7/31/2001	0.33	0.04	0.05	0.37	7.18
Willow Cr. 50 yds. d/s of Heppner City Park, river mile 55.3	7/31/2001	0.17	0.04	0.03	0.21	6.41
Willow Cr. 50 yds. d/s of Heppner City Park, river mile 55.3	8/1/2001	0.12	0.05	0.03	0.17	5.58
Willow Creek @ USGS Gage at Heppner (below Reservoir site)	6/7/1973	0.37	0.03	6.00	0.40	0.07
Willow Creek @ USGS Gage at Heppner (below Reservoir site)	6/8/1972	0.13	0.03	0.18	0.16	0.89
Willow Creek @ USGS Gage at Heppner (below Reservoir site)	3/21/1972	0.31	0.03	0.15	0.34	2.27
Below Reservoir Summary ►	mean	0.51	0.11	0.39	0.62	5.59
	median	0.32	0.07	0.09	0.44	5.13
	count	28	28	28	28	28

Above-Reservoir Site Descriptions	Date	NO2+NO3 (mg/l as N)	Ammonia (mg/l as N)	Ortho-P (mg/l as P)	DIN (mg/l as N)	DIN/Ortho-P
Willow Cr. 1/4 mi. u/s of Reservoir under Hwy. Bridge	8/1/2001	0.03	0.06	0.06	0.09	1.41
Willow Cr. 1/4 mi. u/s of Reservoir under Hwy. Bridge	7/31/2001	0.02	0.04	0.06	0.06	1.04
Willow Cr. 1/4 mi. d/s of Blake Ranch Rd., river mile 69.3	7/31/2001	0.0025	0.03	0.03	0.03	1.02
Willow Cr. 1/4 mi. d/s of Blake Ranch Rd., river mile 69.3	8/1/2001	0.0025	0.05	0.03	0.05	1.64
Willow Cr. 1/4 mi. u/s of Cutsforth Park, river mile 77.3	8/1/2001	0.01	0.02	0.01	0.03	2.91
Willow Cr. 1/4 mi. u/s of Cutsforth Park, river mile 77.3	7/31/2001	0.01	0.03	0.01	0.04	4.40
Above Reservoir Summary ►	mean	0.01	0.04	0.03	0.05	2.07
	median	0.01	0.04	0.03	0.05	1.52
	count	6	6	6	6	6

Other Site Descriptions	Date	NO2+NO3 (mg/l as N)	Ammonia (mg/l as N)	Ortho-P (mg/l as P)	DIN (mg/l as N)	DIN/Ortho-P
Reservoir at floating dock near Balm Fork	7/31/2001	0.0025	0.04	0.003	0.04	17.00
Reservoir at floating dock near Balm Fork	8/1/2001	0.0025	0.02	0.01	0.02	4.50
Reservoir at floating dock near Balm Fork	7/31/2001	0.0025	0.04	0.003	0.04	17.00
Heppner Waste Water Treatment Plant Effluent	8/9/2001	9.25	5.70	2.65	14.95	5.64
Heppner Waste Water Treatment Plant Effluent	10/9/1999	10.70	5.20	2.57	15.90	6.19
Heppner Waste Water Treatment Plant Effluent	10/2/2005		1.00			
Heppner Waste Water Treatment Plant Effluent	11/2/2005		1.16			
Heppner Waste Water Treatment Plant Effluent	12/6/2005		2.80			
Heppner Waste Water Treatment Plant Effluent	1/4/2006		2.10			
Balm Fork Will Cr. @ Gage @ Balm Fk. Rd. Xng.	7/31/2001	0.59	0.10	0.14	0.69	4.83

Gray shading indicates 1/2 of the detection limit used for less-than-detectable analytical results.

Brown shading indicates assumed value based on similar day measurement

DIN: Dissolved inorganic nitrogen = nitrate + nitrite + ammonia

Ortho-P: Orthophosphorus (dissolved organic P_2O4^{-3})

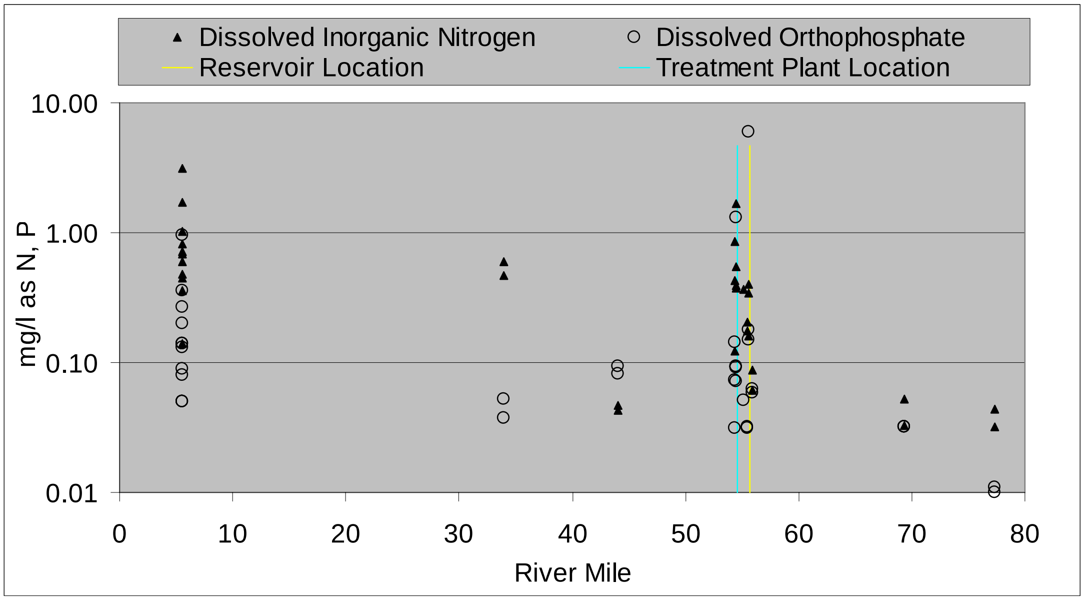


Figure E-9. *Longitudinal distribution of dissolved nutrient concentrations in Willow Creek. Data from* ***Table E-3****.*

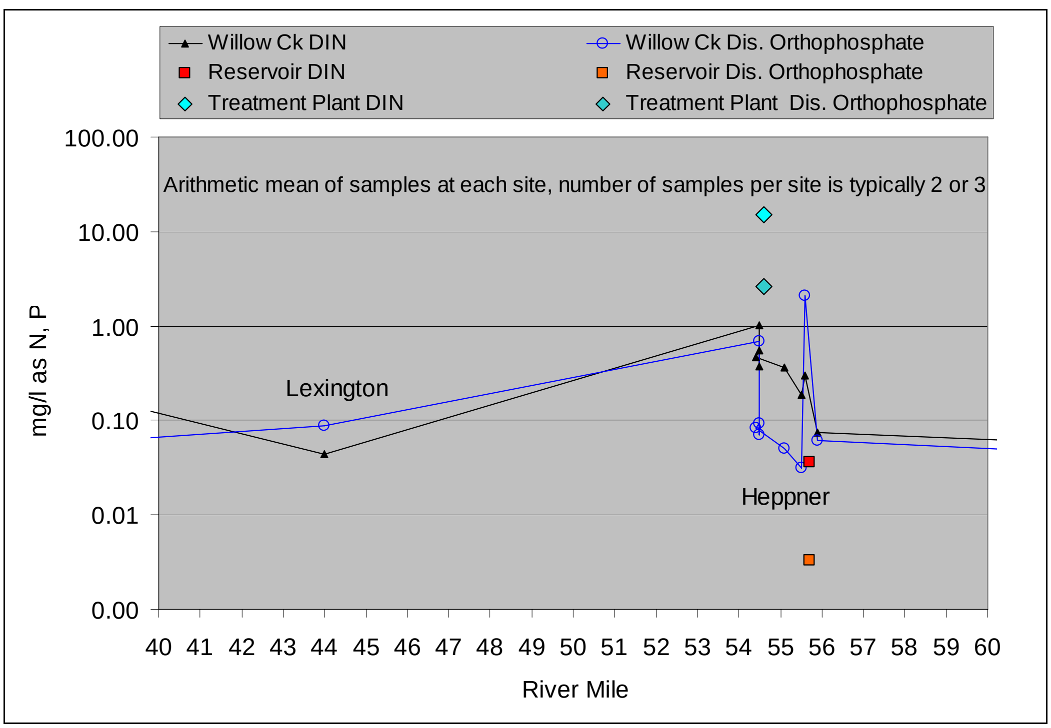


Figure E-10. *Longitudinal distribution of mean concentrations of dissolved nutrients in Willow Creek in Heppner-Lexington area (same data as Figure E-9, except Reservoir and Heppner WWTP monitoring is included). Data from* ***Table E-3****.*

Algae consume nitrogen and phosphorus at a fixed ratio. Therefore if one nutrient is in short supply, it will limit the growth of algae regardless of the concentration of the other nutrient. When the nitrogen:phosphorus concentration ratio is less than 7, algal growth is significantly more influenced by nitrogen than phosphorus concentrations. In Willow Creek, N:P is generally less than 7, both above and below the Reservoir (**Table E-3)**. Accordingly, point sources of nutrients should be limited to DIN concentrations that would be assimilable without increasing algal mass enough to cause pH standard exceedances downstream. This DIN concentration is not known, as computer modeling was not employed for reasons discussed below. By targeting the median ambient DIN concentration, these sources would not have the potential to increase algal growth. From **Table E-3**, the median ambient DIN is 0.44 mg/l as nitrogen (for this purpose considering all Willow Creek sites below the Reservoir, except for the reach between the WWTP and Lexington). However, greater concentrations may not be adverse, particularly since algal mass and pH is relatively low in the Heppner area, and Lexington, where high pH was measured, is roughly 10 miles downstream. Furthermore, the pH exceedances at Lexington are few, slight (**Figures E-3** and **E-7**) and within the margin of measurement error (±0.3 standard pH units). The maximum pH measured at Lexington was 9.16 in 2001.

It would be possible to apply mechanistic modeling and determine the potential for nutrient discharges near Heppner to influence Willow Creek pH at Lexington. However, the lack of flow below Lexington and Ione would preclude the necessary model calibration in lower reaches, and hence prohibits fully addressing the issue in the lower River. Also, given that the 303(d) listing basis has been addressed and that the criteria exceedance at Lexington was within measurement error and may no longer manifest in the same reach under the recently increased summer flow, modeling is not warranted. Increased Reservoir outlet discharge since 2003 is likely to have moved continuous surface flow further downstream; increased flow and reservoir aeration should serve to moderate temperature and pH for some distance below the Dam (unfortunately the latest data is from 2001). Despite the absence of quantitative analysis, it is clear that improvements related to the temperature TMDL implementation and flow increase would support pH moderation (and dissolved oxygen improvement as well).

Included in the rationale for a non-quantitative approach to addressing pH in lower Willow Creek, other factors mitigate the potential concern of high pH and dissolved oxygen near Lexington:

- Predictions of pH through modeling are hampered by a lack of stream data since 2001, and the uncertainty of future flow. Post 2001 and future potential changes in Reservoir management include: aeration, increased summer time outflow due to the establishment of irrigation rights, changes in withdrawal elevation/depth, and future potential prospect of irrigation district establishment.
- The pH monitoring site at Lexington is more than ten miles downstream from the individual NPDES discharges, providing substantial time and distance for attenuation of nutrient impacts from the point sources.
- The Heppner treatment plant has a BOD_5 limit, providing control in relation to DO and nutrients (high organic nutrient content that could later convert to soluble or inorganic forms, would lead to high BOD).
- Not meeting pH and DO criteria at Lexington or further downstream could be a natural condition due to stagnation – and Willow Creek may have been intermittent prior to human modification of the watershed.

E4. Lower Subbasin pH Approach and Follow Through

It may make sense to conduct further pH assessment and possibly modeling in the future, with monitoring tailored to newly established flow patterns – patterns that may yet be influenced by factors such as TMDL implementation and the potential establishment of an irrigation district. The recent NPDES permit renewal for the City of Heppner includes the requirement for monitoring of DIN in effluent during the warm season in which land application occurs. The next permit renewal for the Oregon Co-Gen facility should similarly require nitrogen monitoring. Periodically, monitoring should address a wider suite of nutrients and related parameters as well.

Given the situation, the Department will address pH below Heppner as follows:

- Notify the point source authorities that after a longer-term flow regime is established and as temperature TMDL implementation improves conditions below Heppner, pH may be re-evaluated. If temperature TMDL/flow related improvements do not eliminate pH concerns at Lexington, or if other downstream site pH or DO measurements are outside of standards, the Department may assess the downstream impacts of nutrients from point sources. This could lead to more stringent effluent limits for the two individual NPDES facilities.
- Temperature TMDL implementation, flow restoration and ongoing monitoring should be the focus for at least the next ten years.
- As a precaution, point sources will be limited to their current loading, with regard to dissolved inorganic nitrogen. More data is needed to statistically characterize current loading. It is suggested here that once a statistically representative number of June through September samples is achieved, trend analysis should show no significant increase.
- Reservoir operations should be conducted to minimize nutrient output as well. Ongoing aeration may well achieve this. Attention should be given to nutrient concentrations as withdrawal elevations, aeration and discharge alternatives are weighed by the USACE; balancing pH, temperature and other water quality concerns.

E5. Summary

Willow Creek has exceeded the water quality standard for pH at Heppner and Lexington. The pH exceedances at Heppner are the basis for the current 303(d) listing and are attributable to the Willow Creek Reservoir. Reservoir aeration-mixing and selective-depth withdrawal can demonstrably address the pH concern, together or separately. A pH target of 6.5-9.0 should be assigned to the Reservoir in the TMDL.

Whether elevated pH still occurs at Lexington is unknown but remains possible there or further downstream, even with recent summer increases in Reservoir outflow, due to low flow conditions (warm stagnant waters) and lack of stream shading in this area and below. Discussions with community residents indicate that continuous flow extends further downstream with the increased Reservoir outflow, however not by a great distance. Instream flow restoration would lead to decreased afternoon pH levels and decreased pH diel fluctuation – and would also help address dissolved oxygen concerns identified during TMDL monitoring. The temperature TMDL planning calls for more natural channel, riparian and flow conditions that will improve pH, and DO levels as well.

There is no evidence that point sources contribute to downstream impairment with regard to pH. As a precaution, point sources will be limited to their current loading.

At this time, and pending increased flow in Willow Creek and further monitoring, the Department believes that reservoir control sufficiently addresses pH concerns on Willow Creek at Heppner, and encourages ongoing monitoring to verify this. The Department recommends Willow Creek management that is protective of natural instream flows. The Department will encourage and support temperature TMDL implementation (leading to pH and DO moderation as well). Ongoing monitoring should be considered by DEQ or other organizations, as priorities allow, to further evaluate pH and dissolved oxygen levels in Willow Creek below Heppner.

E6. Citations

Allan, J. D., 1995. Stream Ecology. Chapman and Hall. 388p.

Cascade Earth Sciences, August 2003. Preliminary Impact Assessment for Proposed Rapid Infiltration Gallery Port of Morrow Generating Facility, Heppner, OR. PN:2322007/August 2003.

DEQ, 1995. 1992-1994 Water Quality Standards Review – Final Issue Papers. Oregon Department of Environmental Quality, Standards and Assessment Section.

Funk, W. H., 1973. Willow Creek Reservoir water quality study. Final Report to U.S. Army Corps of Engineers, Walla Walla District, Washington. Environmental Engineering Laboratories, Washington State University, Pullman. 50 p.

Larson, Douglas, W., 1997. Limnological and Water Quality Studies 1984-1996, Final Report (to US Army Corps of Engineers)

EPA, 1986. Quality Criteria for Water.

DEQ

State of Oregon
Department of Environmental Quality

Appendix F: Stream Bacteria Assessment

F1. Introduction and Background

This bacteria assessment in the Willow Creek Subbasin includes Willow Creek and the Willow Creek Reservoir, but largely focuses on the Balm Fork of Willow Creek. This monitoring and assessment evaluates the Balm Fork 303(d) listing (**Table F-1**) and makes recommendations regarding Total Maximum Daily Load development. The TMDL stemming from this assessment is reported in **Section 1.5** of the main document.

Table F-1. *Willow Creek Subbasin bacteria 303(d) listing*

Record ID	Waterbody Name	River Mile	Parameter	Season	List Date
5262	Balm Fork	0 to 9.5	Fecal Coliform	Summer	1998

The Balm Fork listing is the only bacteria listing in the Subbasin. Though the listing data is from the 1980's, ongoing data acquisition indicates that the water quality standard is exceeded through 2001 in Balm Fork and potentially elsewhere in the Subbasin. The Department has recruited substantial data in the Subbasin, from a variety of organizations, and is not aware of any data collected since 2001.

The Balm Fork watershed is approximately 26 square miles, has no forest area, is used for livestock grazing (cattle primarily), occasional rural residences and pheasant habitat and hunting. Typical yearly flow ranges from 0.01 to 21 CFS (0.0003-0.59 CMS). There are no NPDES permitted facilities or sources in the Watershed. The Balm Fork drains directly into Willow Creek Reservoir. The Reservoir is used for recreation including fishing and swimming, irrigation, and flood control.

This document addresses data and methods for TMDL development. Some complicating factors are noted here, and should be kept in mind while reviewing this appendix: (1) the 303d listing and much of the available bacteria data consist of fecal coliform analyses, whereas the standard is now based on *E. coli*, (2) data were not collected frequently enough to support calculation of the bacteria water quality standard's log mean criteria, (3) the *E. coli* data are not paired with flow measurements, other than a downstream flow gage ranging from 0-7 miles (0-12 kilometer) from the sampling points, and (4) the *E. coli* data set is short term. This assessment describes how these hurdles are addressed and recommends follow-up monitoring.

Average vs. Instantaneous Concentration Target

In the bacteria water quality standard, there is an average concentration target and an instantaneous concentration target (**Table F-2**). The average concentration target is the log mean of at least 5 samples over 30 days, whereas the instantaneous concentration target is applied to any given sample. This TMDL targets the log mean concentration criterion. This target was chosen because it most directly relates to illness rates[1] and is a more stable indicator of fecal contamination. The management practices that

[1] From Implementation Guidance for Ambient Water Quality Criteria for Bacteria (EPA, EPA-823-B-02-003, May 2002 Draft, pg 7): "For the purpose of analysis, the data collected at each of these sites were grouped into one paired data point consisting of an averaged illness rate and a geometric mean of the observed water quality. These data points were plotted to determine the relationships between illness rates and average water quality (expressed as a geometric mean). The resulting linear regression equations were used to calculate recommended geometric mean values at specific levels of protection (e.g., 8 illnesses per thousand). Using a generalized standard deviation of the data collected to develop the relationships and assuming a log normal distribution, various percentiles of the upper ranges of these distributions were calculated and presented as single sample maximum values.

control fecal bacteria to achieve the log mean concentration target will also control loading associated with the peak concentrations. That said, the instantaneous target should also be considered as the TMDL is implemented.

If future monitoring shows peak concentrations that are consistently exceeding the instantaneous sample criteria, DMAs will be asked to modify their management plans to address these peak loads. This is discussed in the Water Quality Management Plan of this document (**Part 2**).

Table F-2. *Bacteria water quality numeric criteria for freshwater. Organisms of the coliform group commonly associated with fecal sources may not exceed the following criteria (OAR 340-041-0009):*

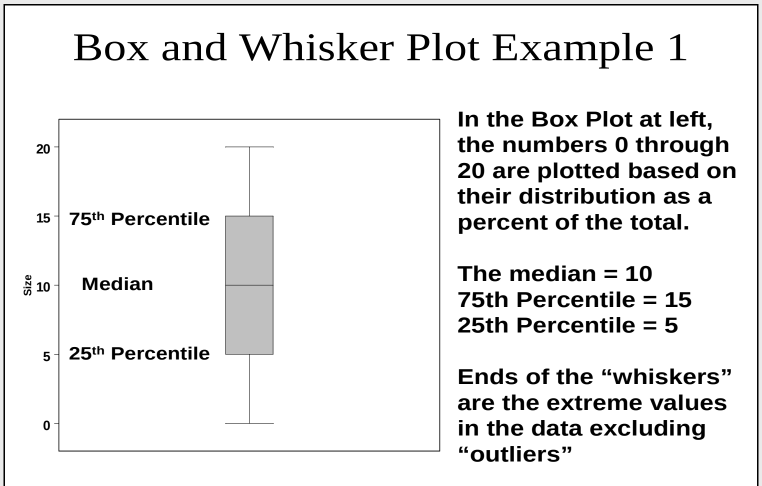
	30-day log mean, based on a minimum of 5 samples:	Instantaneous Criteria (no single sample may exceed):
E. coli Concentration	126 organisms/100 milliliter	406 organisms/100 milliliter

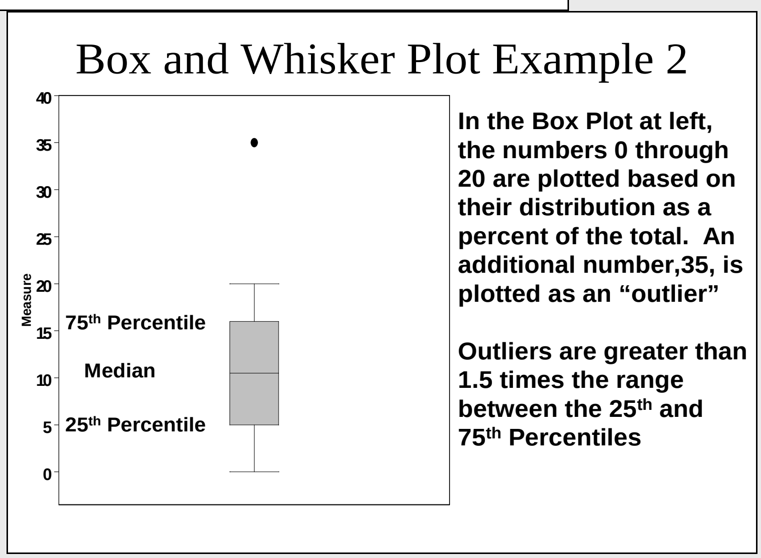
A log mean is also called a geometric mean, and is a type of average. A log mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the result if an arithmetic mean were used. The log mean is the arithmetic mean of the logarithms of sample concentrations.

Measurements of bacteria can range from 0 to over 10,000 organisms in a 100 milliliter water sample. When data varies so much over a wide range, the numbers are often transformed into logarithms. This makes many of the calculations easier and allows the data to be displayed more clearly on graphs. This means that values on the scale go from 1, to 10 (10^1), to 100 (10^2), to 1,000 (10^3), to 10,000 (10^4) and so forth. It is standard to report bacteria concentrations in units of number of organisms per 100 milliliter – often noted in this text as counts/dl, an abbreviation for number of organisms per deciliter.

Note that the box plots in this Appendix are standard, unlike those found in the pH assessment of this document. For pH the box shoulders are the 10^{th} and 90^{th} percentiles, with no outlying data shown. This is designed to facilitate comparison of the 90^{th} percentile with water quality standard criteria. In this bacteria Appendix, the shoulders are quartiles as is more typical for box plots, with whiskers including data outside of the quartiles by 1.5 times the interquartile range. Outliers beyond the whiskers are shown as well. Further description of box plots is illustrated in the following inset.

Box Plots are used to illustrate the distribution of samples through time or among places. The percentile indicates the percentage of sample values less than the value at that point in the distribution. In example 1 below, 75%of sample values are lower than 15 and 25% are lower than 5. By definition, the median is the 50th percentile, with 50% of values lower and 50% of values higher than the median.





The measurement of bacteria concentrations can vary considerably. Samples taken at the same time and place will probably not yield exactly the same result. Analysis of 227 duplicate fecal coliform samples collected in Oregon during 1996 and 1997 showed that samples varied more at higher concentrations, see **Table F-3**.

Table F-3. *Summary of bacteria data collected throughout Oregon during 1996 and 1997 (personal communication, DEQ Watershed Section)*

Results of 1996/1997 sample analysis (counts/dl)		
Range Assessed	Average Value	Average Difference
6-33	**16**	**8**
203-810	**318**	**91**

F2. Monitoring

Water quality monitoring in Willow Creek Subbasin has been implemented through DEQ, USACE, USGS, the City of Heppner and volunteer efforts. Further information concerning monitoring times and locations are described in **Appendix C** and subsequently in this Appendix.

F3. Spatial Patterns

Willow Creek

Fecal Coliform data are available for Willow Creek for the period from 1972 to 2001. *E. coli* analysis was not implemented for Willow Creek samples until recently, in part because the *E. coli* was not selected as a water quality standard indicator species by the State of Oregon until 1996. The 1996-1997 volunteer monitoring, addressing *E. coli* as an analyte, focused on 303(d) listed Balm Fork rather than Willow Creek. The 2001 TMDL bacteria monitoring included *E. coli*, however that quantity of data is relatively slight. Accordingly bacteria patterns in Willow Creek are assessed via fecal coliform measurements.

Fecal coliform concentrations generally increase downstream, whether looking at long-term (**Figure F-1**) or near term (**Figure F-2**) data. The Willow Creek Reservoir is an obvious exception, where the majority of analytical results are less than detectable. This is presumably because extended residence time in the Reservoir allows for bacterial die-off. In both **Figure F-1** and **F-2**, there is a difference in the values in the Reservoir and the site immediately downstream. Part of this is because samples were not all collected at the same time and the Reservoir sampling depth or location is not necessarily representative of the outlet (particularly before the Reservoir aeration project). It is noteworthy that that Balm Fork does not appear to be generating a chronic problem within the main body of the Reservoir. Eighty percent of the Reservoir bacteria samples yielded results of less than the detection limit.

The paucity of *E. coli* data hinders evaluation for that species. Even so, there is sufficient correspondence between *E. coli* and fecal coliform concentrations (**Section F4**) to suggest that the *E. coli* water quality standard is likely to have been exceeded elsewhere than Balm Fork – in Willow Creek at the mouth, at Lexington and immediately above the Reservoir. Other Willow Creek monitoring sites data either meets both criteria or there is not enough data to draw any conclusions.

The most recent monitoring at the mouth occurred in 1975, and as Willow Creek bacteria levels appear to be generally decreasing through time (discussed below), this may not be a current issue. Follow-up monitoring may be warranted after the SB1010 process has been underway for several years and after evolving flow patterns, which should influence the bacteria distribution, become more established. At Lexington, twelve of the available fourteen samples are from 1973 or earlier. The remaining two, collected in 2001, have analytical results of 240 and 700 counts/dl. This correlates linearly to 216 and 645 *E. coli* counts/dl (n=22, r^2=0.93, discussed later in this chapter). This suggests a recent and potentially ongoing issue of concern. The remaining site of likely exceedance is just above the Reservoir, and has sufficient data with high concentrations to document a potential ongoing concern. Though data were not collected with a frequency enabling calculation of 30-day log means (at any Subbasin site), for this site a rough estimate of that statistic can be made by aggregating data through longer time intervals. The aggregate log means for the period of record and for 2000-2001 are 119 and 156 counts/dl, respectively. Using the same linear regression just mentioned, these values correlate to *E. coli* concentrations of 103 and 138 counts/dl, suggesting a possible exceedance of the *E. coli* log mean criteria of 126 counts/dl.

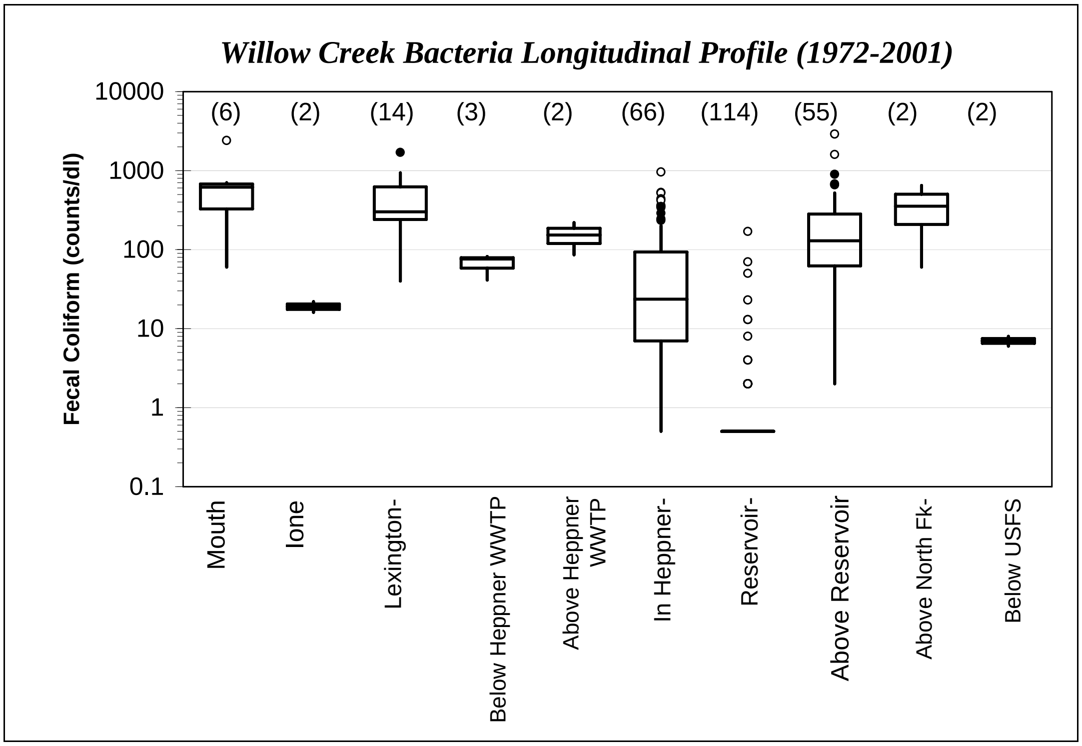


Figure F-1. *Long term box plot of Willow Creek longitudinal fecal coliform concentrations*

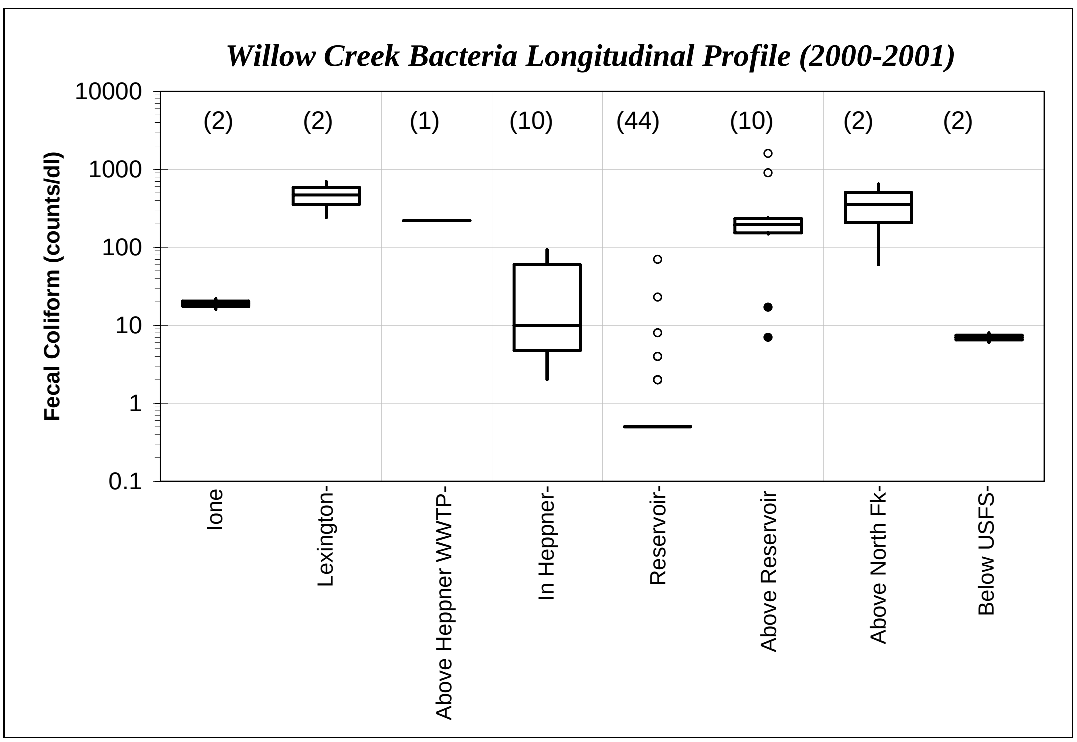


Figure F-2. *Recent data longitudinal box plot of Willow Creek fecal coliform concentrations*

Balm Fork

During 1996 through 2001, TMDL/303(d) bacteria monitoring was conducted along Balm Fork with focus on *E. coli*. In addition, in the early 1970's, mid 1980's and 1987-2001 the USACE and USGS monitored fecal coliform concentrations at the USGS gage site near the mouth of Balm Fork as well as elsewhere in the Heppner area. As shown in **Figure F-3**, which aggregates year-round data, Balm Fork *E. coli* concentrations generally increase downstream, with a decrease at the mouth. The latter is perhaps due to increased dilution by ground water. This pattern still holds when viewing only months of highest concentration, June through August (discussed in following sections). **Figure F-4** portrays the June through August data longitudinally. **Figures F-3** and **F-4** include a site at the mouth of Gilman Canyon, which is a tributary confluencing with the Balm Fork between the two uppermost Balm Fork sites.

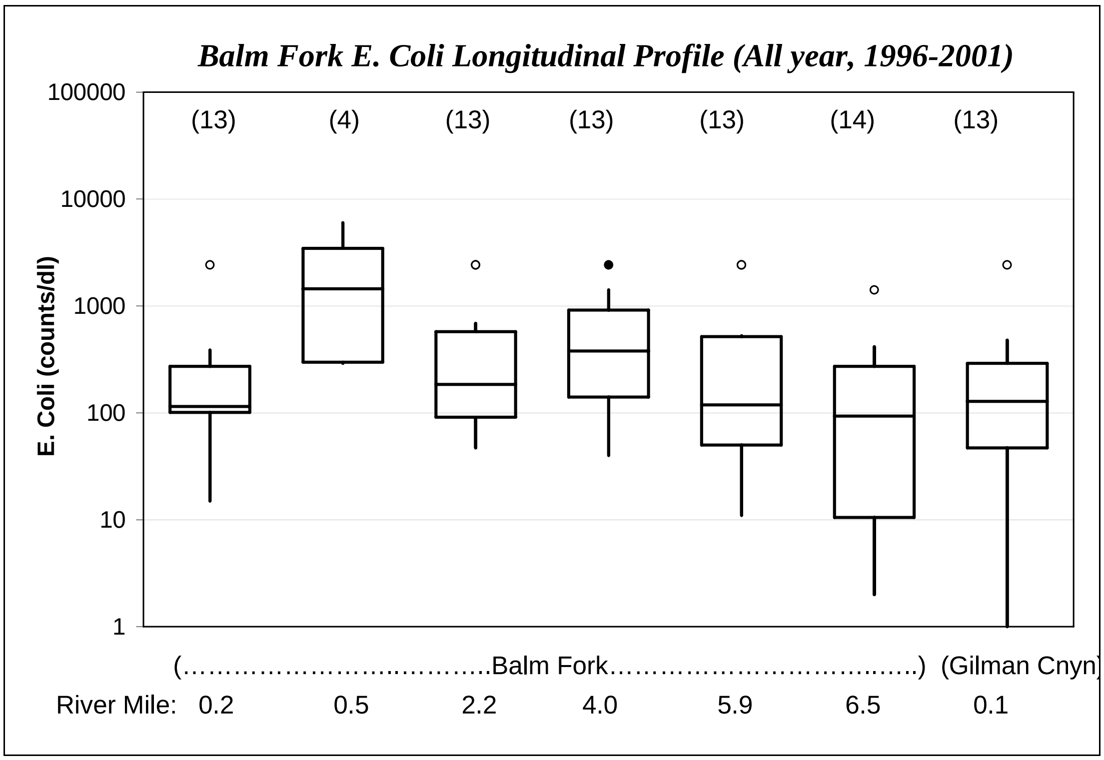


Figure F-3. *Period of record longitudinal box plot of Balm Fork E. coli concentrations, year round data set*

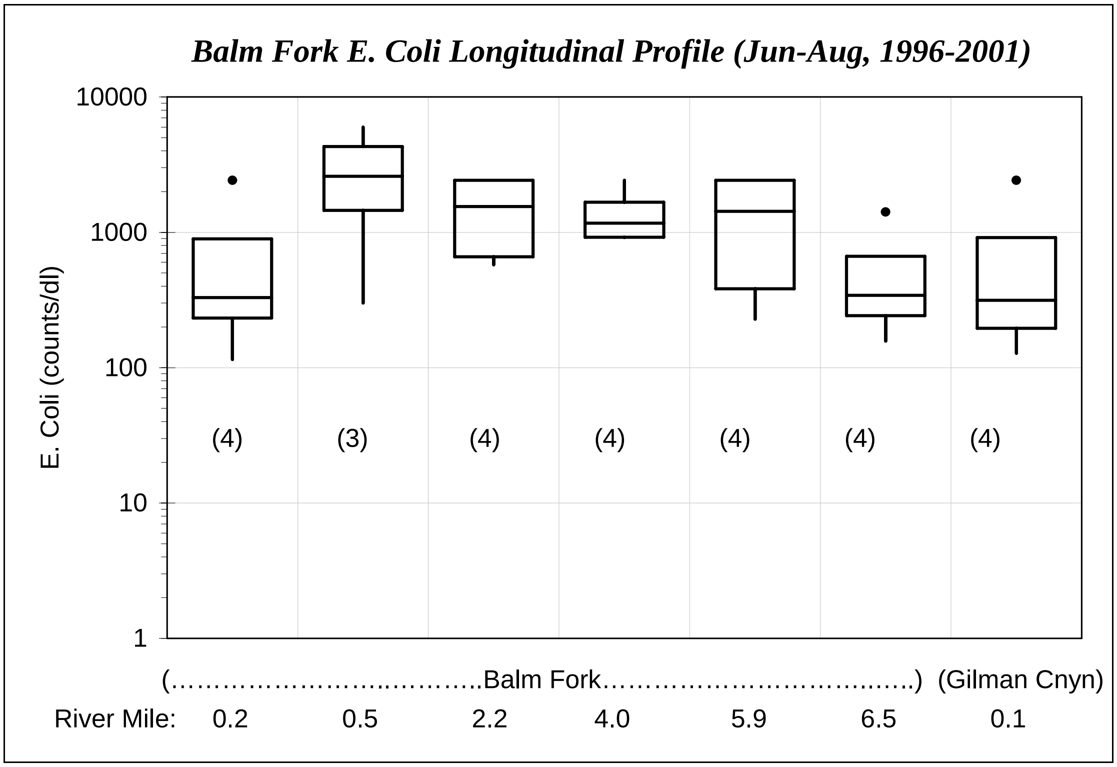


Figure F-4. *Period of record longitudinal box plot of Balm Fork E. coli concentrations, June through August only*

As indicated in **Figures F-3** and **F-4**, the instantaneous criterion (406 counts/dl) is exceeded at some point in time at every site on Balm Fork. At four sites all individual sample values exceed the log mean criteria, and therefore a log mean calculation would very likely exceed log mean criteria as well. Intra-annual patterns are described subsequently (**Section F5**).

F4. Comparative Analysis

Balm Fork Compared to Willow Creek

Balm Fork can be compared to Willow Creek on the basis of fecal coliform bacteria concentrations. As mentioned previously, there is generally insufficient Willow Creek *E. coli* data for robust analysis. However, comparative basis is provided by the USACE and USGS monitoring for fecal coliform in both systems. Note that the Balm Fork fecal coliform data were only collected at the mouth of the stream. **Figure F-5** is a box plot comparing the fecal coliform concentrations at the mouth of Balm Fork with nearby and background sites on Willow Creek. Balm Fork has greater median and 75th percentile concentrations than any site on Willow Creek. The median fecal coliform concentrations for the Balm Fork and Willow Creek one quarter mile above the Reservoir, are 228 and 130 counts/dl, respectively.

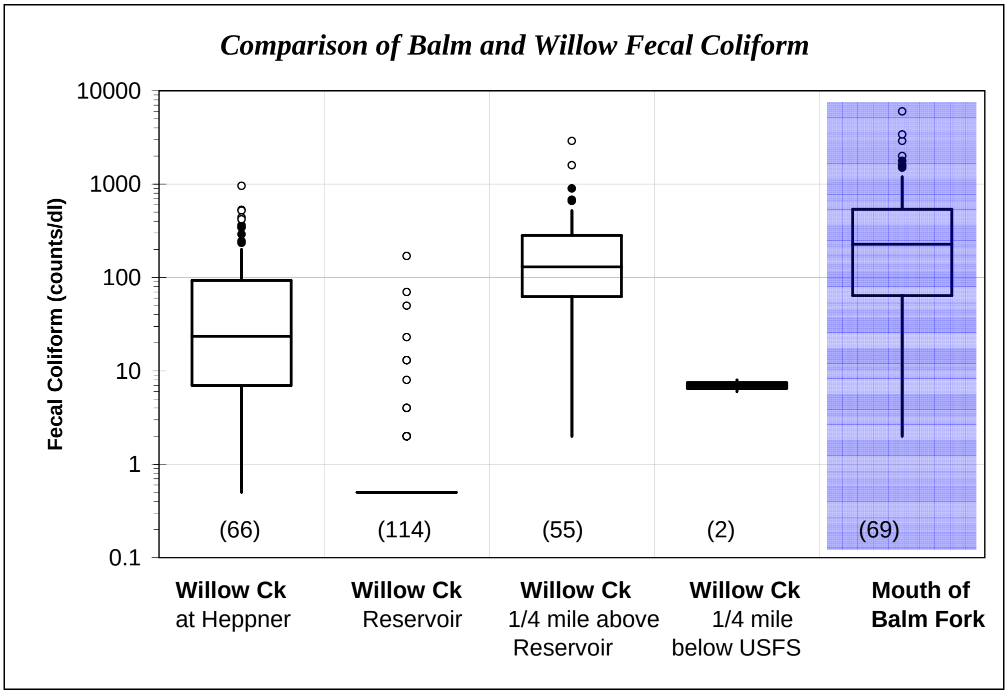


Figure F-5. *Box plot comparing year round fecal coliform concentrations at various sites near Heppner and one upper watershed site, all years of data collection*

Fecal Coliform Compared to *E. coli*

Fecal Coliform and *E. coli* concentrations appear to be well correlated in the Willow Creek Subbasin. This is apparent in **Figure F-6**. From the Willow Creek regression equation, the Willow Creek fecal coliform value correlating to the *E. coli* log mean water quality criterion (126 counts/dl) is 143 counts/dl, based on 22 data pairs from 1996-2001. The Balm Fork correlative value should be generally disregarded due to low number of pairs (5) and is not dissimilar to the Willow Creek correlate.

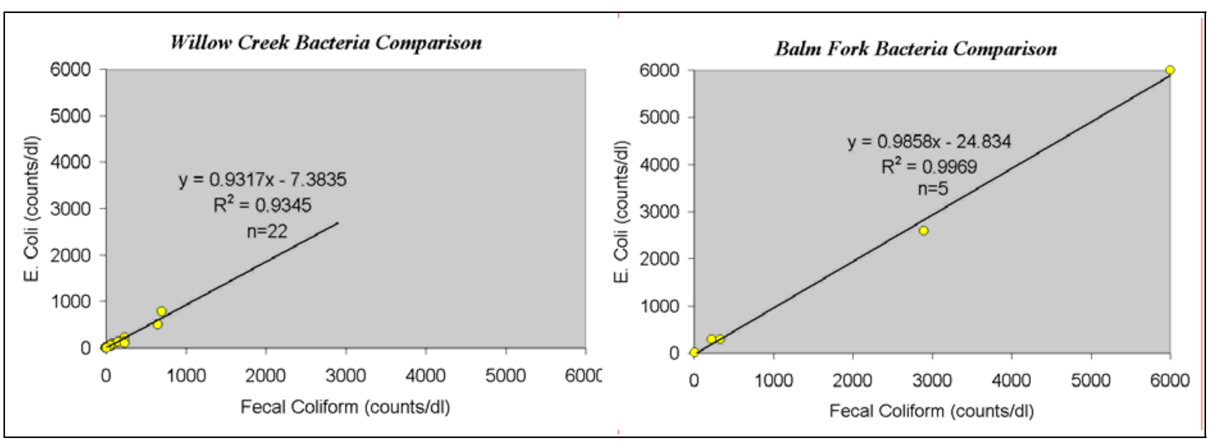


Figure F-6. *Linear regressions of E. coli versus fecal coliform from Willow Creek and Balm Fork, aggregating data from all sites having paired data*

Natural Background

Perspective can be gained regarding natural background bacteria levels by assessing data from areas that have little human-based contribution. In Willow Creek and surrounding basins, it is generally the case that human-related bacteria sources are rare in upper forested parts of watersheds. Septic systems, point sources and livestock are relatively infrequent in these areas. The DEQ LASAR database was queried for bacteria analytical results at sites meeting these criteria within Willow Creek and neighboring basins. The results are summarized in **Figure F-7**. The concentrations of *E. coli* in nearby relatively natural watersheds are substantially less than in Balm Fork (compare **Figure F-7** to **Figures F-3** and **F-4**). The Department acknowledges that comparing watersheds of differing sizes and elevations has limitations as an approach to determining background, and this is done primarily because of a lack of comparable sites without human influence. However, this does shed some light; and a quantification of background, though desirable, is not essential to this assessment. Long term monitoring of Willow Creek Subbasin areas where bacteria reduction measures are applied would be beneficial.

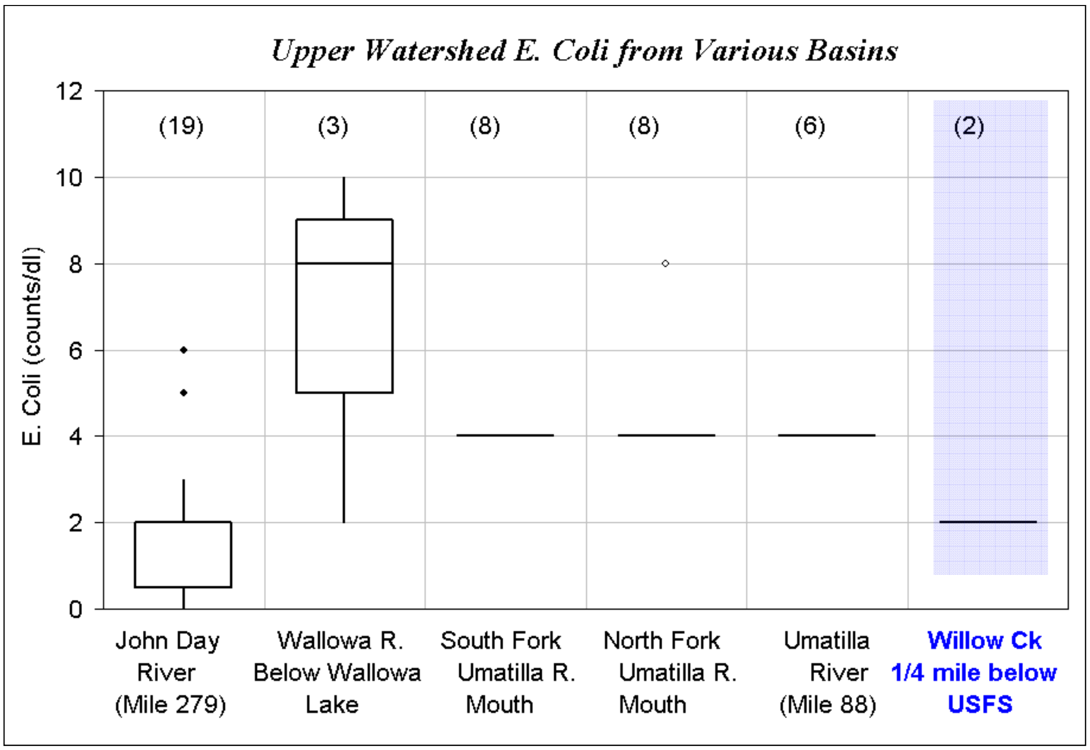


Figure F-7. *Upper watershed E. coli concentrations from various sites in or near Willow Creek, all available times*

F5. Temporal Patterns

Time patterns are reviewed on intra- and inter-annual scales. Long term patterns can be discerned via the fecal coliform data, available for Willow Creek and Balm Fork since 1972. Analysis of *E. coli* was not implemented in the area prior to 1996. In the Balm Fork watershed, sufficient data exists to evaluate seasonal (monthly) patterns for both *E. coli* and fecal coliform data.

Willow Creek, Fecal Coliform – Long Term (1972-2001)

Yearly fecal coliform concentration versus time is shown in **Figure F-8**, suggesting a downward trend in median values since the 1970's. Annual medians appear to have a distinct decreasing trend. In order to evaluate the statistical significance of a potential downward trend, a seasonal Kendall test was run. Two trends are shown in both **Figures F-9a** and **F-9b**, a simple linear regression and the more robust Sen-Theil-Kendall line (nonparametric, selects median slope of lines connecting all possible pairs of bacteria data). Seasons were delineated by segregating the highest four consecutive months, and then the middle and lowest, in terms of median concentrations of fecal coliform for all Willow Creek sites excluding the Reservoir. Season 1 is defined as July through October, Season 2 is March through June and Season 3 is November through February. The decreasing trend of Season 2 (**Figure F-9a**), the season with the highest fecal coliform concentration, is statistically significant, with a P-value of 0.007 (**Table F-4a**). By definition P-values range from one to zero and reflect the probability of rejecting the hypothesis that no trend exists. The generally accepted threshold for rejecting a lack of trend is P<0.05.

Because the Reservoir strongly influences the site immediately below it (**Figures F-1** and **F-2**), the Seasonal Kendal procedure was run again to separate out Reservoir influence – all pre-Reservoir data (before 1985) from the City of Heppner reach was removed. The next downstream pre-Reservoir site is Lexington, which is probably not greatly influenced by the Reservoir. Note that the trend is less steep, but a statistically significant reduction is still evident, with P=0.01 in March through June (**Figure F-9b**, **Table F-4b**).

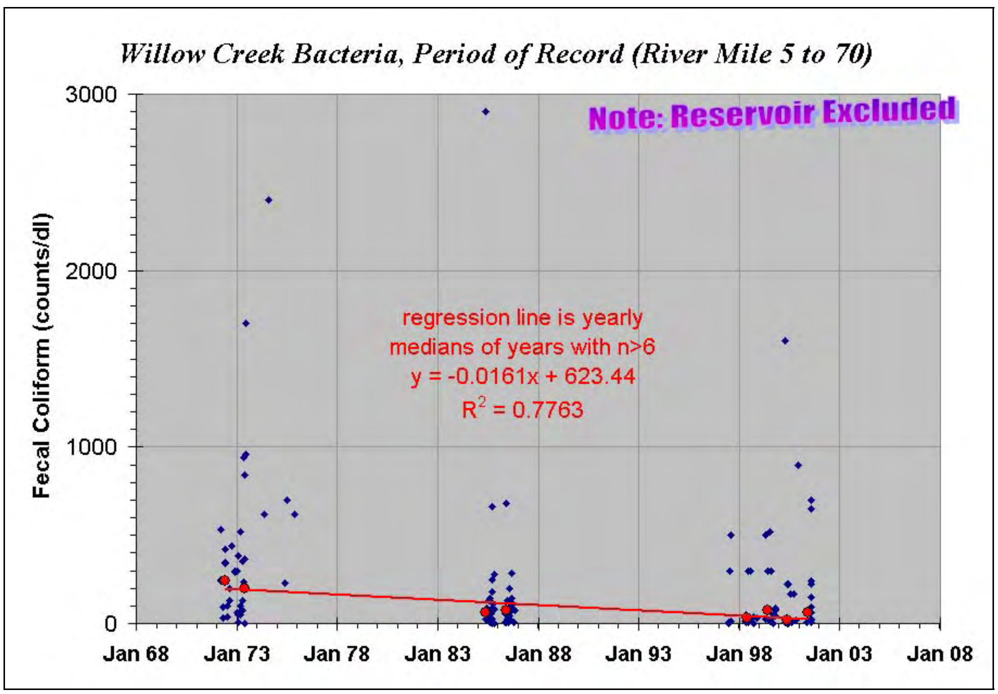


Figure F-8. *Fecal Coliform concentrations aggregated from all data sites along Willow Creek, except the Reservoir site. Small symbols are individual samples, larger symbols (red) are annual medians for the years addressed.*

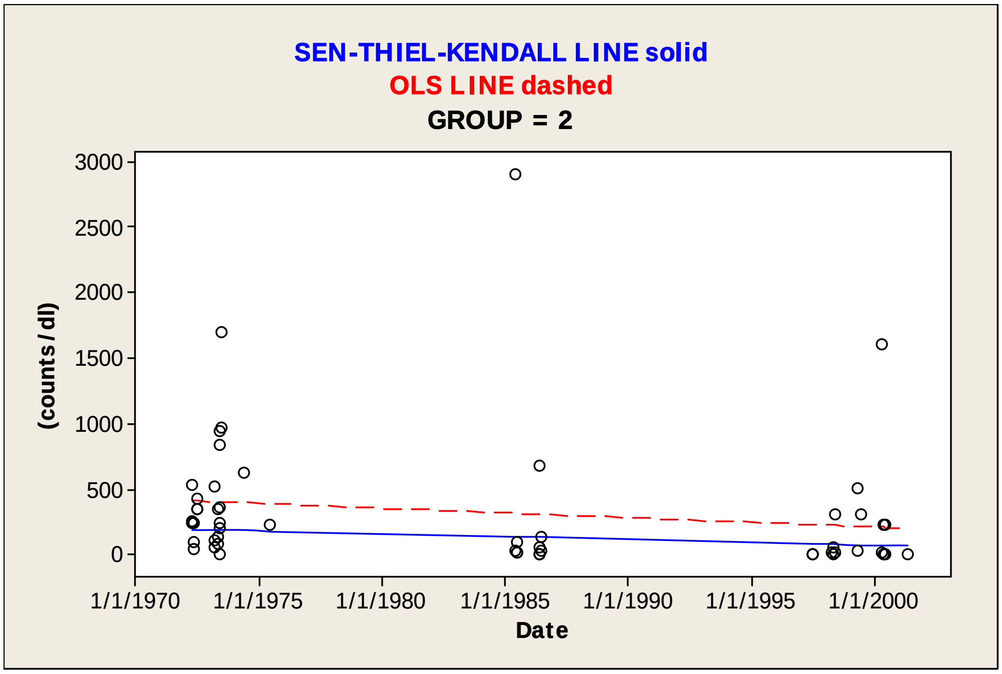


Figure F-9a. *Seasonal Kendal assessment for Fecal Coliform concentrations from all Willow Creek sites, except the Reservoir (OLS is ordinary least squares method of simple linear regression)*

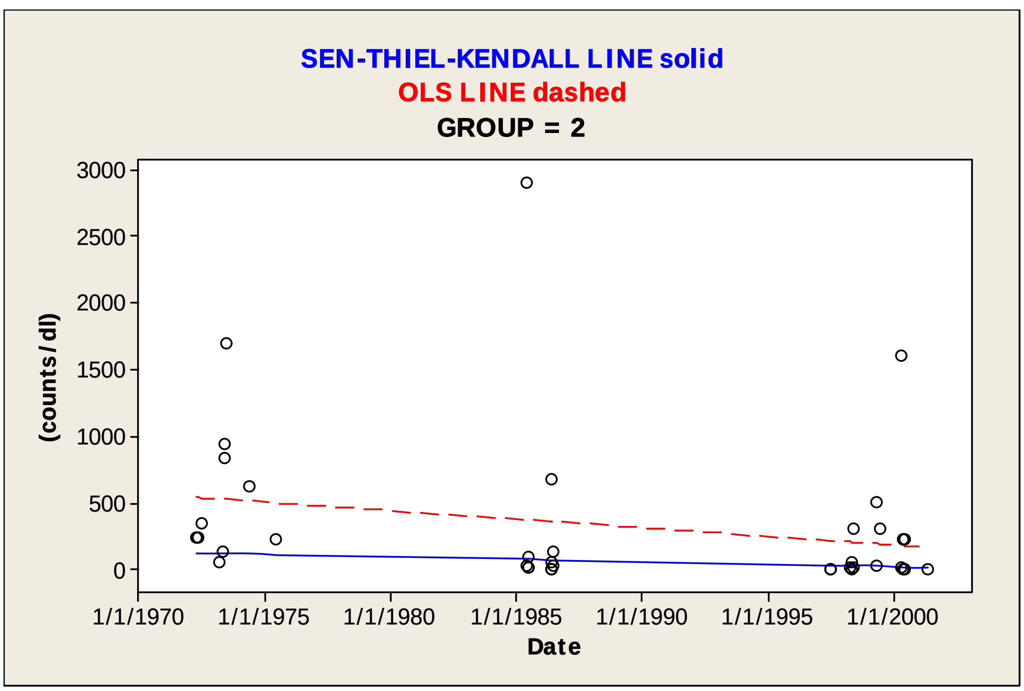


Figure F-9b. *Seasonal Kendal assessment for Fecal Coliform concentrations from all Willow Creek sites, except the Reservoir and pre-Reservoir Heppner Sites (OLS is ordinary least squares method of simple linear regression)*

Table F-4a. *Willow Creek fecal coliform seasonal Kendall test tabular output (1972-2001). Aggregate data set with all Willow Creek data except Reservoir.*

Data segregated by Season

Row	SEA2	N_SEA	S_TAU	TAU_A	Z_S	P_VALUE	INTRCEPT	SLOPE
1	1	86	-134	-0.036662	-0.49668	0.61941	103.381	-0.0010539
2	2	53	-349	-0.253266	-2.67371	0.00750	507.247	-0.0120928
3	3	13	0	0.000000	0.00000	1.00000	75.000	0.0000000

Aggregate Data combining all seasons

Row	N_ALL	S_ALL	TAU_ALL	Z_ALL	PVAL_ALL	SEAINTER	SEASLOPE
1	152	-483	-0.0945021	-1.61655	0.105976	175.246	-0.0030799

Table F-4b. *Willow Creek fecal coliform seasonal Kendall test tabular output (1972-2001). Aggregate Willow Creek data except Reservoir and pre-Reservoir Heppner data have been removed.*

Data segregated by Season

Row	SEA2	N_SEA	S_TAU	TAU_A	Z_S	P_VALUE	INTRCEPT	SLOPE
1	1	81	7	0.002160	0.02451	0.98045	62.000	0.0000000
2	2	38	-201	-0.285917	-2.52177	0.01168	393.185	-0.0102064
3	3	8	1	0.035714	0.00000	1.00000	259.303	0.0014958

Aggregate Data combining all seasons

Row	N_ALL	S_ALL	TAU_ALL	Z_ALL	PVAL_ALL	SEAINTER	SEASLOPE
1	127	-193	-0.0486024	-0.745650	0.455879	113.867	-0.0013850

Willow Creek, Fecal Coliform: Intra-annual

As shown in **Figure F-10**, the four months where median values of the aggregate Willow Creek data set are greatest are: November, March, May and June, with insufficient data to evaluate January, February and December.

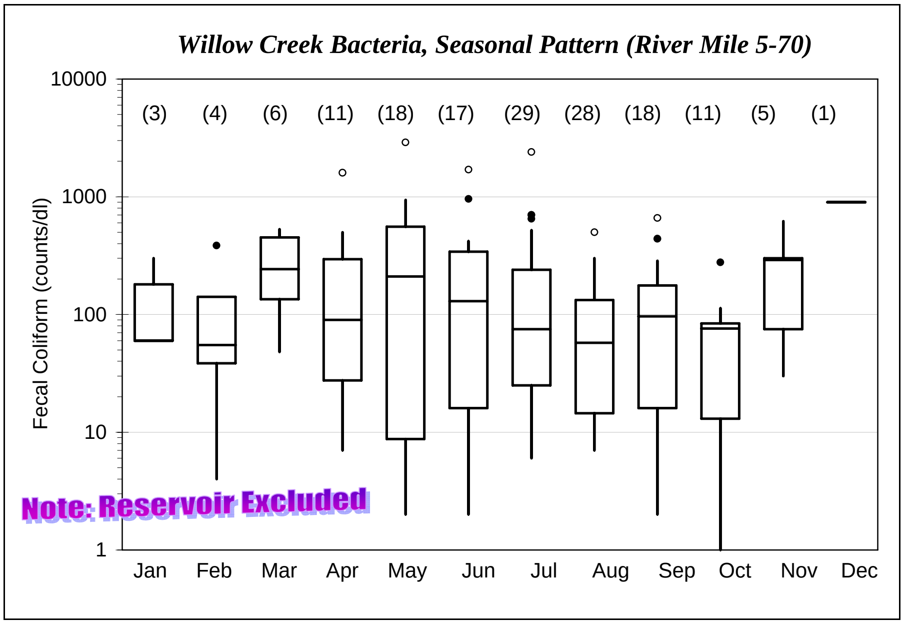


Figure F-10. *Fecal Coliform intra-annual distribution from 1972-2001 dataset of all Willow Creek sites combined, except the Reservoir site*

Balm Fork, Fecal Coliform – Long Term (1972-2001)

A decennial downward trend for the Balm Fork, similar to that of Willow Creek, is suggested by the trend of yearly median Fecal Coliform concentration in **Figure F-11** (correlation is low, but residuals fair). The early data are small in number, however the similarity to the more robust pattern on Willow Creek suggests a Subbasin-wide improvement including the Balm Fork.

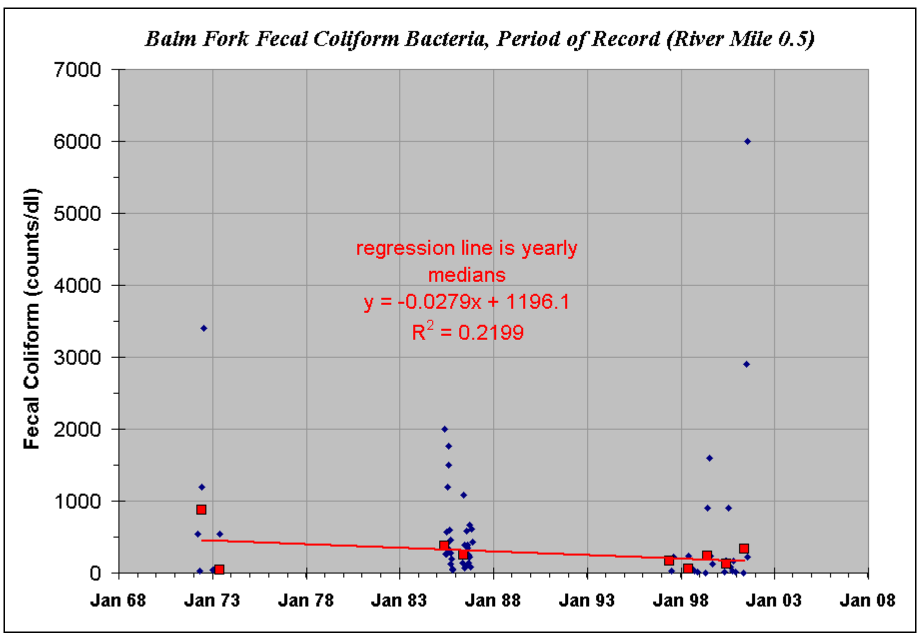


Figure F-11. *Long term fecal coliform data from the USGS gage site near the mouth of Balm Fork. Small symbols are individual samples, larger symbols (red) are annual medians for the years addressed.*

Statistical significance of this apparent trend was tested using the Seasonal Kendall method (**Figure F-12, Table F-5**) which did validate the existence of a trend of reducing concentrations through time, thought that trend is slight.

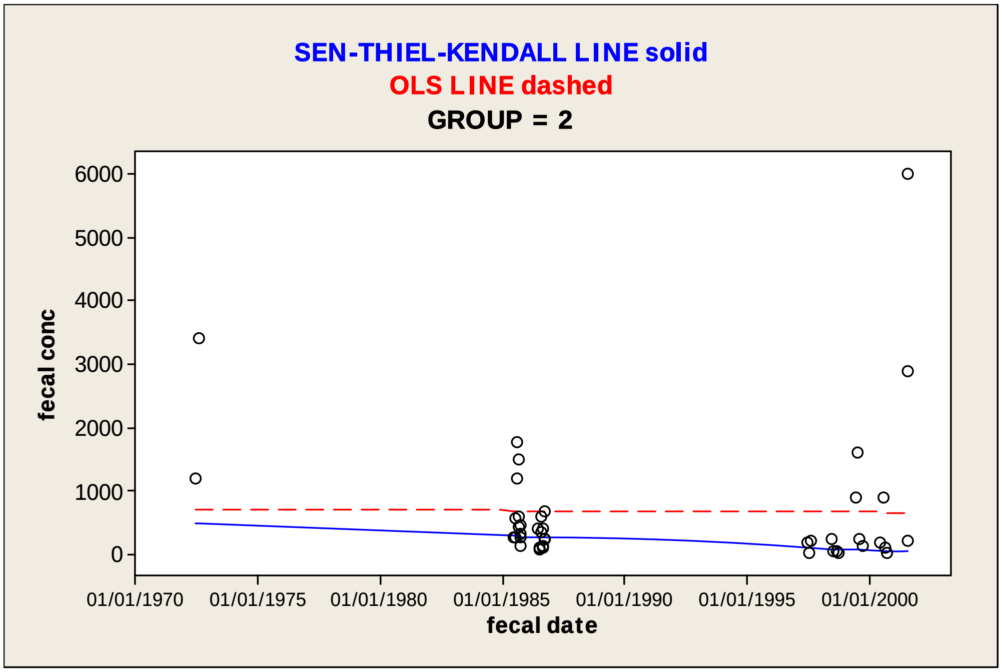


Figure F-12. *Fecal coliform Seasonal Kendall test output based on data from gage site near Balm Fork mouth, season 2, June through September*

Table F-5. *Balm Fork fecal coliform seasonal Kendall test tabular output (1972-2001)*

Data segregated by Season

Row	SEA2	N_SEA	S_TAU	TAU_A	Z_S	P_VALUE	INTRCEPT	SLOPE
1	1	15	-2	-0.019048	-0.04955	0.96048	114.22	-0.0010847
2	2	44	-232	-0.245243	-2.33735	0.01942	1562.96	-0.0410988
3	3	10	-1	-0.022222	0.00000	1.00000	93.14	-0.0008558

Aggregate Data combining all seasons

Row	N_ALL	S_ALL	TAU_ALL	Z_ALL	PVAL_ALL	SEAINTER	SEASLOPE
1	69	-235	-0.214416	-2.30571	0.0211270	1189.75	-0.0303861

Balm Fork, *E. coli* – Short Term (1996-2001)

The *E. coli* data was evaluated for trend as well. Due to the high variance and the short term of the data (1996-2001), no trend is detected over this period. First, the spatial-aggregate *E. coli* data set was plotted against time (**Figure F-13**). The paucity of 1996 and 2001 data argues against any statistical validity. A Seasonal Kendal test was run as well, segregating months into groups of February-May, June-September and October-January. As above, this segregation is intended to combine consecutive months into groups based on median bacteria concentrations. No seasonal nor overall statistically valid trend was detected (**Table F-6**, P>0.05 for each season).

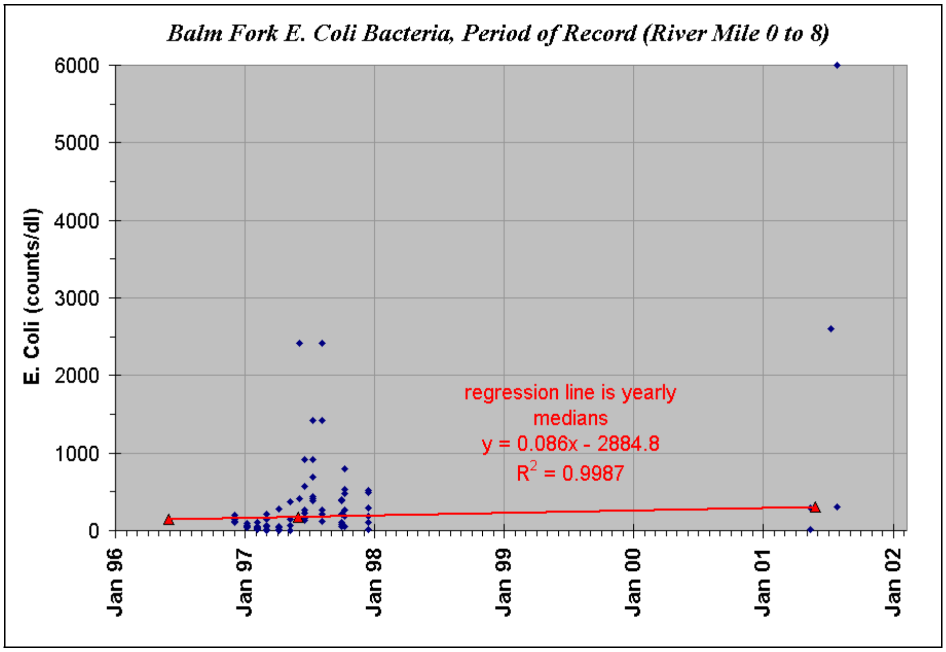


Figure F-13. *Long term E. coli data from all Balm Fork sites combined. Small symbols are individual samples, larger symbols (red) are annual medians for the years addressed.*

Table F-6. *Balm Fork E. coli seasonal Kendall test tabular output (1996-2001)*

Data segregated by Season

Row	SEA2	N_SEA	S_TAU	TAU_A	Z_S	P_VALUE	INTRCEPT	SLOPE
1	1	26	23	0.070769	0.49928	0.617580	-2765.86	0.079133
2	2	27	-10	-0.028490	-0.19425	0.845983	687.00	0.000000
3	3	30	82	0.188506	1.47926	0.139071	-9825.29	0.279241

Aggregate Data combining all seasons

Row	N_ALL	S_ALL	TAU_ALL	Z_ALL	PVAL_ALL	SEAINTER	SEASLOPE
1	83	95	0.0855086	1.11663	0.264154	-4115.78	0.120828

Balm Fork, Fecal Coliform – Intra-annual

The intra-annual pattern for Balm Fork fecal coliform concentration is shown in **Figure F-14**. The months where median values of the aggregate data set are greatest are: July, November, August, June, September and May, in decreasing order, with insufficient data to evaluate January through March, November and December. Note that Balm Fork and Willow Creek both have relatively high fecal coliform concentrations in November, June, September and May, whereas they tend to differ in July and August, with Balm Fork concentrations ranking high in these months.

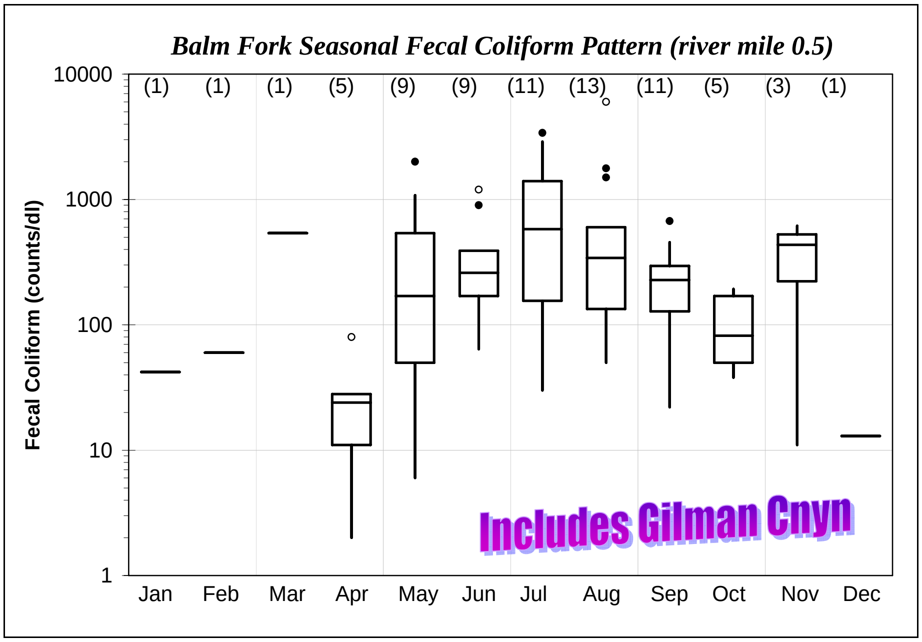


Figure F-14. *Fecal Coliform intra-annual distribution from USGS gage site near mouth of Balm Fork*

Balm Fork, *E. coli* – Intra-annual

The intra-annual pattern for Balm Fork *E. coli* is shown in **Figure F-15**. The months where median values of the aggregate data set are greatest are: August, June, July, October and December, in decreasing order, with insufficient data to evaluate September.

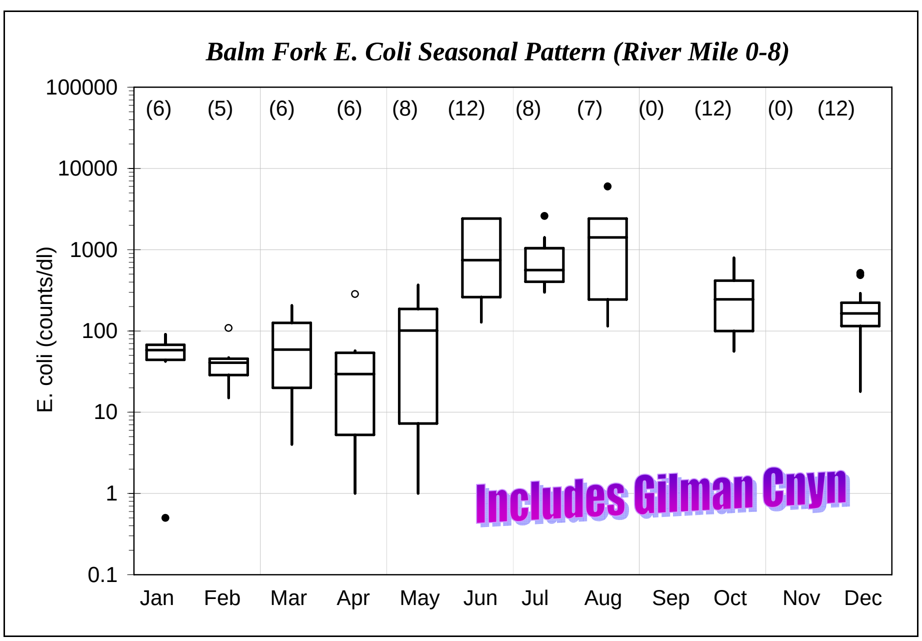


Figure F-15. *E. coli intra-annual distribution from all Balm Fork sites combined*

F6. Flow Patterns

Bacteria concentrations were checked for correlation with flow at both Balm Fork and Willow Creek. Correlation is very low, as is apparent in **Figures F-16** and **F-17**.

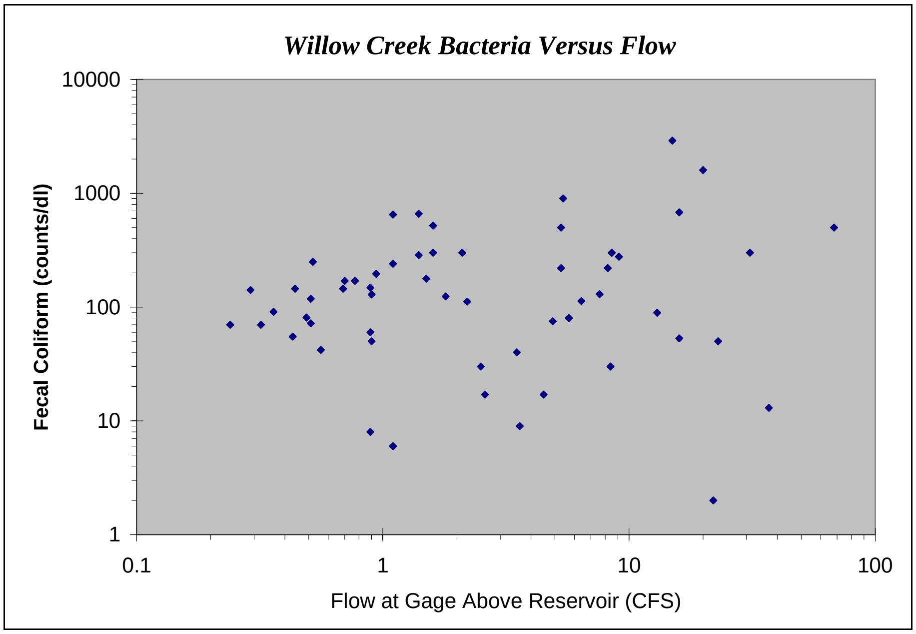


Figure F-16. *Fecal coliform concentrations versus flow in Willow Creek at the stream gage site just above the Reservoir*

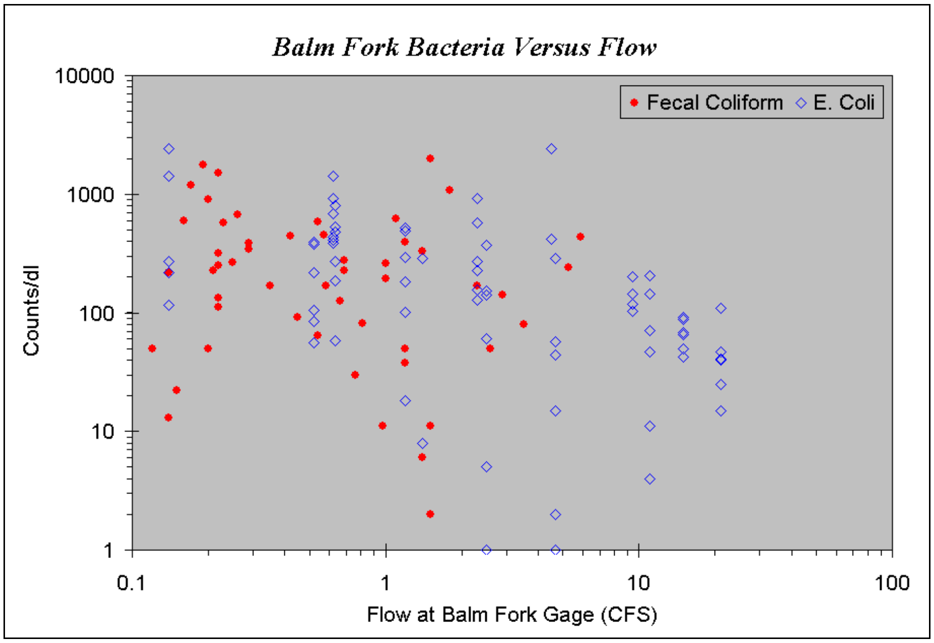


Figure F-17. *Fecal coliform and E. coli concentrations versus flow in Balm Fork at the stream gage site just above the Reservoir*

F7. Load Duration Curves

This section focuses on load duration curves for Balm Fork, as a possible basis for setting Total Maximum Daily Load allocations. Load duration curves have been used in TMDLs [(e.g., the Umpqua River TMDL in Oregon, Kansas Department of Health and Environment (Cleland 2002)] and can provide insights as to pollutant sources. Load duration curves depict relationships between flow and pollutant loading, and can facilitate segregating load allocations by flow range.

Explanation of Load Duration Curves:

Load duration curves are usually established for gage sites having long term records of stream flow, where water quality monitoring has been conducted. The first step is to pair the concentration and flow data. Concentration is then converted to load (load = flow x concentration) and flow is transformed into a ranking such that a column of flow data, still paired with its pollutant load, is represented as 'percent of days of the year that a given flow is exceeded.' This percent exceedance is plotted on the x-axis and the loading on the y-axis. An 'x' of 60% represents a flow that is exceeded 60 percent of the year. Accordingly x=100 indicates dry conditions and x=0 represents flooding. The x-axis is often referred to as 'flow duration interval.'

Development of load duration curves is described explicitly in the bacteria appendix of the Umpqua TMDL, available on the Department's website.

Balm Fork *E. coli*

Balm Fork *E. coli* data was re-calculated in terms of loading based on the flow gage at the mouth of the Balm Fork. **Figures F-18** and **F-19** show that the water quality standard is exceeded at low and mid-range flows. In both figures, the 1996-2001 data is concentrated in 1997 and was collected at a variety of locations along Balm Fork. The gage at the mouth of the Fork was utilized for discharge data, given that flow doesn't vary dramatically along the length of the seven-mile reach sampled.

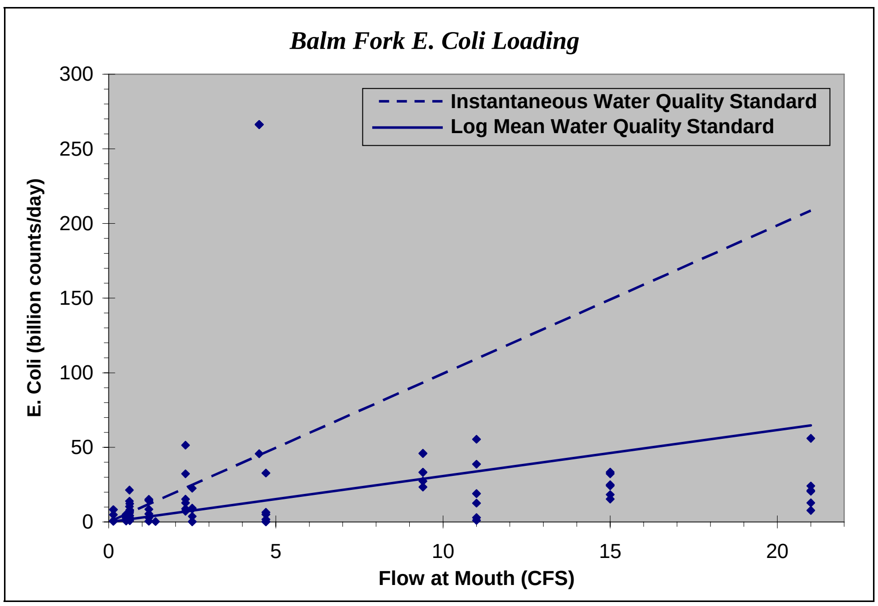


Figure F-18. *Balm Fork E. coli loading related to flow, based on the aggregate data set*

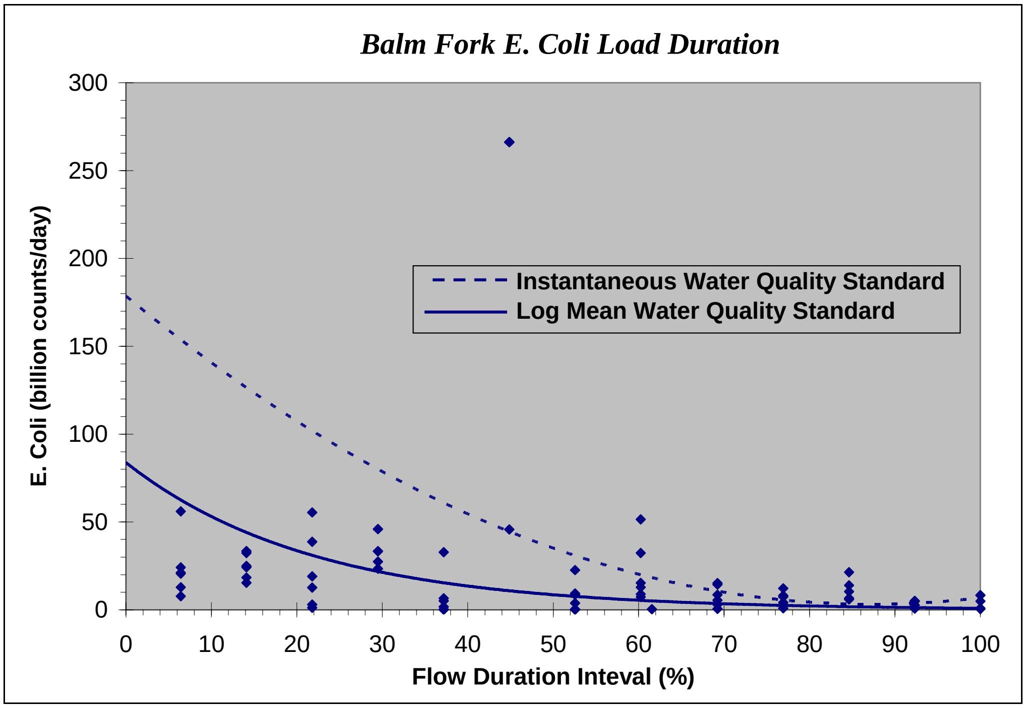


Figure F-19. *Balm Fork E. coli load duration curve based on the aggregate data set*

Balm Fork Fecal Coliform

Fecal coliform load duration curves were prepared for the gage site at the mouth of Balm Fork. Data from this site provide for a much longer record than that of *E. coli*. The fecal coliform reference values in the following graphs correlate with the *E. coli* criteria of 126 and 406 counts/dl, based on the Willow Creek linear regression portrayed in **Figure F-6**. **Figures F-20** and **F-21** indicate that the lower reference value is exceeded at the entire range of flow represented by available data.

Ideally the data should be re-calculated as 30-day log means consisting of at least 5 samples each. This would allow for comparison with the log mean criteria of the standard, designed in part to provide smoothing to reduce the influence of extreme data (outliers). This not possible with the existing data set because monitoring was not conducted with sufficient frequency. To roughly simulate log mean smoothing and magnitude for bacteria in the Balm Fork, log means over longer time spans were calculated for each consecutive 5 samples. This result is shown in **Figure F-22**. It is noted that this approach was not employed for *E. coli* – with the lower quantity of data few log means would have been produced.

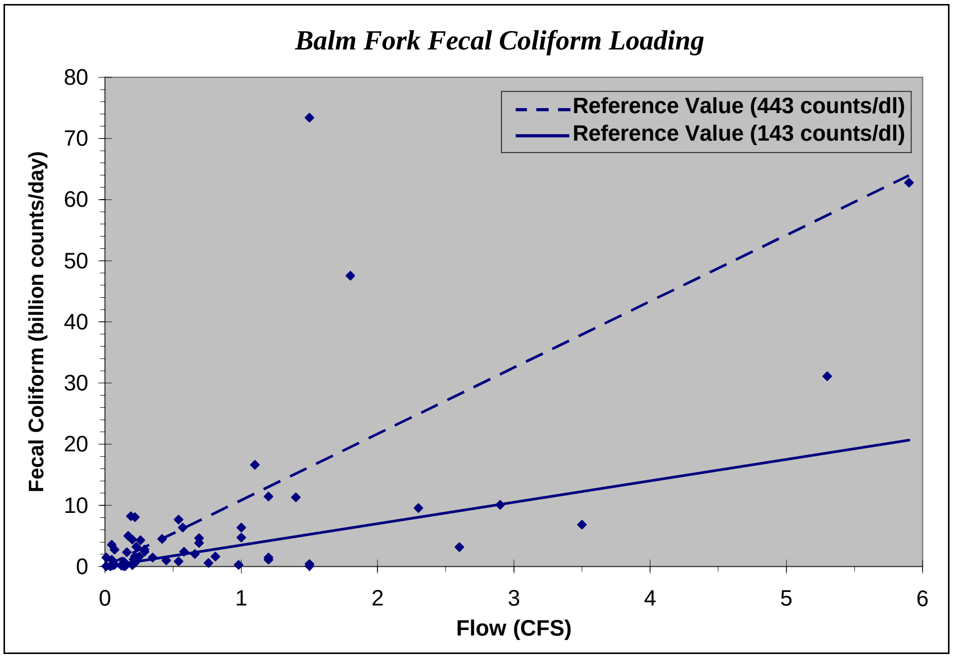


Figure F-20. *Balm Fork fecal coliform loading in relation to flow*

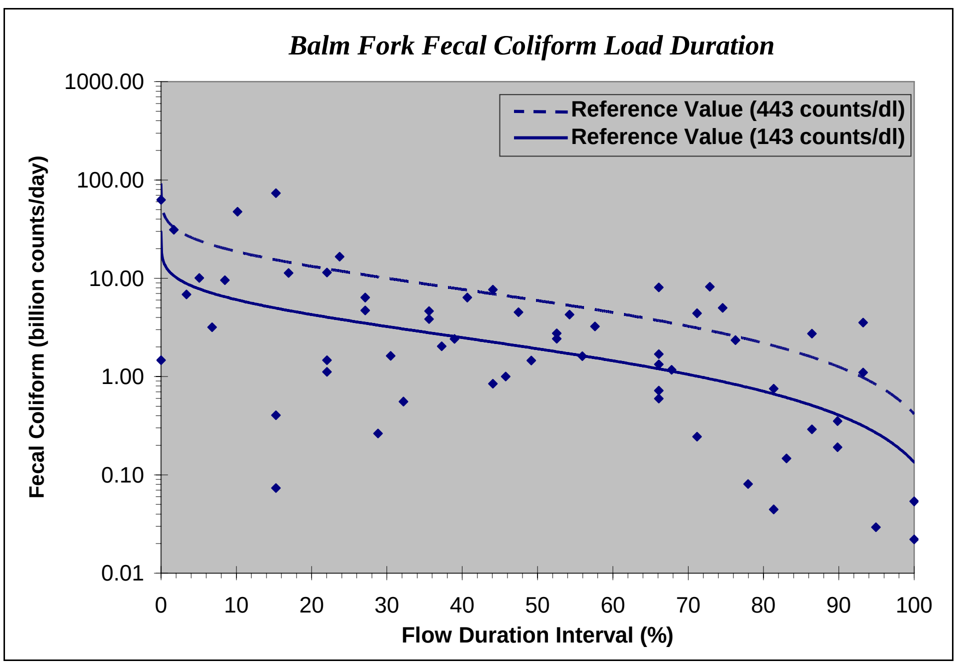


Figure F-21. *Balm Fork fecal coliform load duration curve*

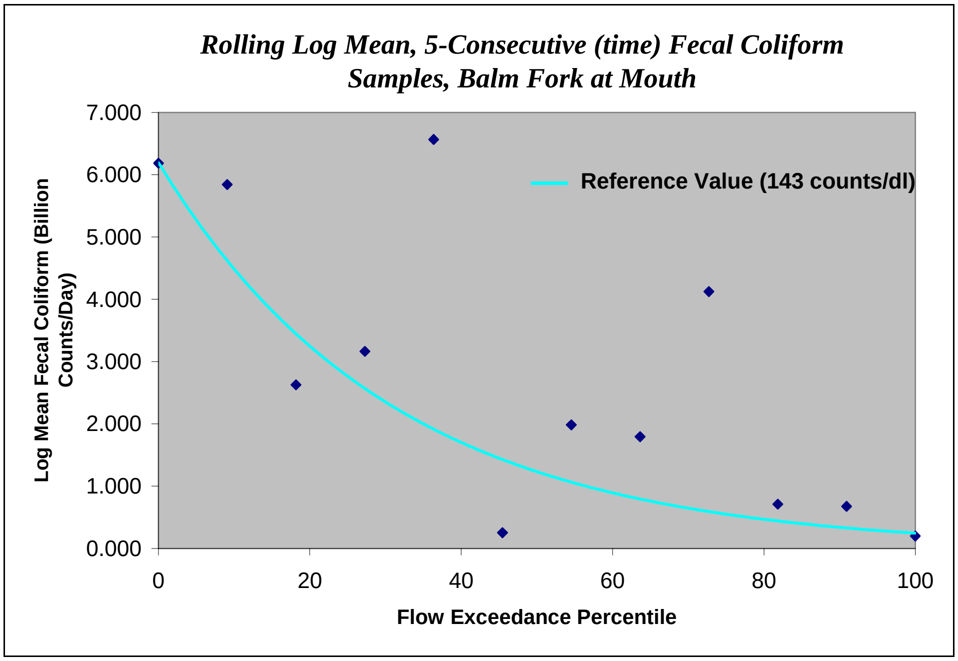


Figure F-22. *Balm Fork fecal coliform load duration curve with data transformed to five consecutive sample log mean values*

F8. Discussion

Load duration curves segregate data by flow, allowing for flow-based source assessment, graphical display of the range of data, and the determination of the critical period for water quality. The *E. coli* load duration curves, **Figures F-18** and **F-19**, suggest setting low and mid-range flow allocations – however, the *E. coli* data set is essentially one year of data. **Figures F-20**, **F-21** and **F-22** indicate that excess fecal coliform loading is occurring throughout the entire range of Balm Fork flow. This implies that there is more than one process of bacteria introduction. Point, near stream, bank and upland sources can often be discriminated through load duration curves by clusters of data exceeding the water quality target – such is not the case in the Willow Creek Subbasin. Stratifying load allocations by flow regime can be facilitated through load duration curves, except here the exceedance is relatively similar through the range of flow, both in loading and concentration. Furthermore, the general downstream increase in bacteria concentration (**Figure F-3**) argues that there is multiple or continuous sources along the Balm Fork. The lack of flow-based pattern suggests that flow, and hence load duration curves, are not the best feature upon which to base load allocations for bacteria on Balm Fork.

The critical period for water quality protection in the Balm Fork watershed is also not apparent through the load duration curves. Instead, the seasonal box plots are more revealing (**Figures F-14 and F-15**). Distinctive intra-annual patterns are visible and argue that bacteria sources or delivery mechanisms, perhaps combined with a lack of dilution in certain months, are most active in June, July, August and to a lesser extent November and May with potential concerns in December and March as well. A clear understanding of land use and management timing in relation to these patterns would be beneficial.

Both Willow Creek and Balm Fork share the general pattern of bacteria concentrations decreasing on a decennial scale and increasing downstream at any given time. The approximate seasonal pattern for Balm Fork (**Figures F-14 and F-15**) is a sharp increase in bacteria concentrations from April through

June, with high concentrations leveling out through August followed by reduction through October and a possible increase in November. This could be explained by either increased bacterial input or less flow for dilution during the summer. The intra-annual patterns of Balm Fork and Willow Creek are different, though similarities exist as well. There is much more month-to-month variability in Balm Fork and July and August are relatively low in Willow Creek and high in Balm Fork whereas the opposite is probably true for March. A further look into these differences may be instructive as to bacteria controls in the Subbasin.

The possibility of addressing Willow Creek with a load allocation was considered by DEQ's Healthy Streams Implementation Group, an internal advisory forum for TMDL decisions. ***The Group recommended that Willow Creek not be addressed with a load allocation***, given the following combined circumstances:

- There is no 303(d) listing for bacteria on Willow Creek, nor does Willow Creek contribute to a bacteria-listed water body.
- There is a statistically significant decennial decreasing trend in the fecal coliform aggregate data set for Willow Creek.
- Much of the fecal coliform data for Willow Creek is old (pre-1980) and no recent data is available (post-2001).
- The dataset consists mainly of fecal coliform measurements - little *E. coli* data is available.
- The Subbasin is addressed through a ODA Agricultural Water Quality Management Area Plan, which addressed bacteria.
- The Department is strategically balancing limited TMDL resources, focusing on required TMDL development and TMDL implementation.

F9. Balm Fork Load Allocation Method

Various load allocation development methods were considered – flow duration curve for *E. coli*, flow duration curve for fecal coliform, instantaneous and log mean targets, delineation by flow interval, etc. The selected gross allotment method is chosen with the intent to focus on *E. coli* and the log mean criteria, given the available data, as follows:

Balm Fork Annual TMDL Excess Load

- Annual log mean *E. coli* = 141 counts /100ml (aggregate 1996-2001 data from all Balm Fork & Gilman Canyon sites)
- Monthly log mean water quality standard = 126 counts/dl
- 10 % margin of safety = 13 counts/dl
- Load allocation: 126-13 =113 counts/dl 30-day log mean, minimum 5 samples
- 100*113/141 = 20 % reduction to achieve water quality goal

Alternative possibilities were not attractive. Comparing log mean (5 consecutive samples over much more than 30 days) fecal coliform data from the mouth to a target of 143 counts/dl calls for variable reductions at the mouth, depending on the flow interval, of 51 percent to zero. With the limited data this is not statistically robust. Delineating flow intervals for *E. coli* has a similar weakness of insufficient data for defensible analysis. The *E. coli* data set is spatially distributed and of short duration (The bulk of the data is from 1997) and does not lend itself to flow evaluation, as typically six samples were collected simultaneously from different locations, only one per set having a flow measurement.

The spatial log mean of all *E. Coli* loads from a given day's monitoring was calculated, using daily flow data from the gage at the mouth of the Balm Fork. This approach is tabulated in **Table F-7**, illustrating the difficulties with assessing loading capacities given this data set. Because one flow is utilized for a six sites, the log mean is a spatial rather than temporal log mean, leading to high variance and poor correlation with flow, and limited correspondence with the water quality target, a temporal log mean.

Table F-7. *Balm Fork Loading Capacities based on a spatial log mean. Though the loading capacities are valid, this approach assessing existing data with a spatial log mean is discarded. The left hand column is the actual daily flow measured during each monitoring event.*

Flow (cubic feet per second)	Loading Capacity (10^9 counts/day)	Loading Capacity minus 10% MOS (10^9 counts/day)	Log Mean Existing Loading (10^9 counts/day)	Percent Reduction Goal
21.0	64.7	58.3	19.7	0
15.0	46.2	41.6	23.9	0
11.0	33.9	30.5	10.9	0
9.4	29.0	26.1	33.9	30
4.7	14.5	13.0	1.9	0
4.5	13.9	12.5	198.6	1491
2.5	7.7	6.9	2.2	0
2.3	7.1	6.4	16.6	160
1.2	3.7	3.3	3.3	0
0.6	1.9	1.7	9.5	455
0.5	1.6	1.4	2.0	40
0.1	0.4	0.4	2.1	445

Future monitoring should be designed to enable calculation of 30-day 5-sample log means in order to evaluate load allocation attainment. In addition, the application of instantaneous criterion on page 1 of this appendix is recalled here: if future monitoring shows peak concentrations that are consistently exceeding the instantaneous sample criteria, DMAs will be asked to modify their management plans to address these peak loads.

General Data Evaluation Summary

- Concentrations generally increase downstream in Willow Creek and Balm Fork.
- Balm Fork does have relatively high bacteria concentrations (at least through 2001) and this may or may not still be the case – there is evidence for long term reduction (Seasonal Kendall P=0.02, March - June). 2001 and prior bacteria concentrations exceed water quality criteria (instantaneous and log mean) and exceed background measurements in forested upstream parts of Willow Creek and neighboring basins. Balm Fork bacteria median concentrations also exceed all sites assessed on Willow Creek.
- Balm Fork bacteria concentration is markedly a function of time of year, as well as generally increasing downstream. A salient seasonal pattern for Balm Fork is a sharp increase in bacteria concentrations from April through June, with high concentrations leveling out through August followed by reduction through October and a possible increase in November. For both Willow Creek and Balm Fork, the correlation of bacteria to flow is very slight.
- The intra-annual patterns of Balm Fork and Willow Creek are different. There is much more month-to-month variability in Balm Fork and July and August are relatively low in Willow Creek and high in Balm Fork whereas the opposite is probably true for March. There is some similarity, both have relatively high bacteria levels in November, June, September and May.
- Excess bacteria in the Balm Fork is likely human or livestock in origin, because other forms of land use are rare and natural background is expected to result in much lower concentrations, as indicated by monitoring in Upper Willow, Upper Umatilla, Upper John Day, Upper Wallowa.
- Excess bacteria in the Balm Fork is unlikely resultant from a single mechanism of production and delivery (e.g., upland and riparian, or human and animal) based on excess loads over a wide range of flows and seasons. And since bacteria concentrations generally increase downstream, plural or spatially continuous sources are indicated.

- Elevated bacteria are not limited to the Balm Fork. Willow Creek likely would exceed the bacteria standard as well, if *E. coli* were measured and if bacteria concentrations have not diminished (not enough data to do TMDL now). Willow Creek is also undergoing apparent long-term reduction in bacteria loading (Seasonal Kendall P=0.01, March –June).
- No short term trend in Balm Fork is apparent (Seasonal Kendall P=0.14-0.85).
- Fecal Coliform and *E. coli* concentrations are well correlated in the Willow Creek Subbasin.

F10. Citations

Cleland, Bruce, 2002. TMDL Development from the "Bottom Up" – Part II: Using Duration Curves to Connect the Pieces, America's Clean Water Foundation

US Environmental Protection Agency, 2002. Implementation Guidance for Ambient Water Quality Criteria for Bacteria (EPA, EPA-823-B-02-003, May 2002 Draft, pg 7)

DEQ
State of Oregon
Department of Environmental Quality