CHAPTER 9: SOUTH SANTIAM SUBBASIN TMDL

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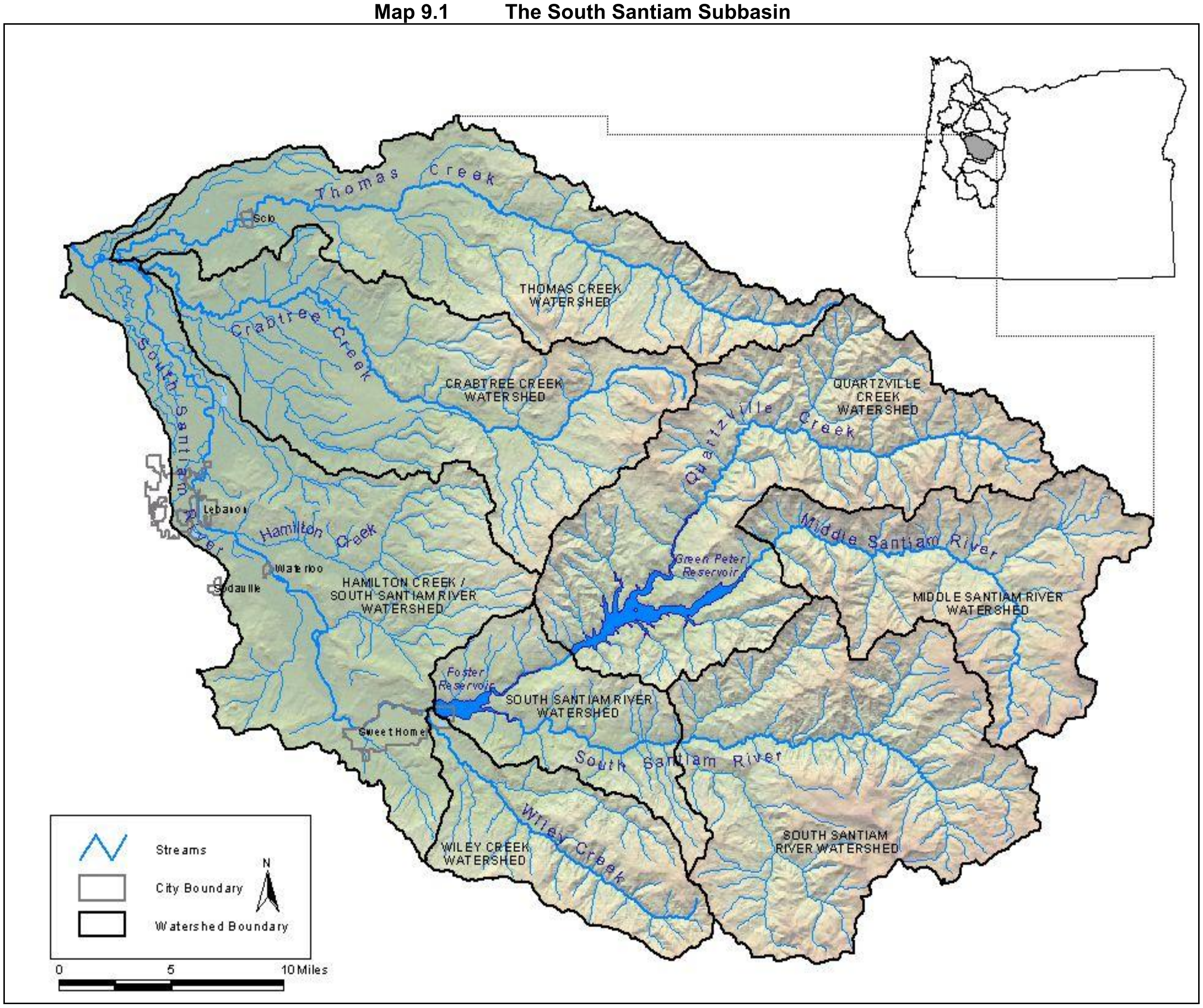
WATER QUALITY SUMMARY

Reason for action

The South Santiam Subbasin (Map 9.1) has stream segments listed under section 303(d)[1] of the federal Clean Water Act (CWA) that are exceeding water quality criteria for temperature. Total Maximum Daily Loads (TMDLs) for temperature are developed based on information for this parameter. Wasteload allocations are developed for individual facilities (point sources) that discharge during the critical period. Load allocations for nonpoint sources are developed for each geomorphic unit and apply to all sectors in the subbasin.

Map 9.1 The South Santiam Subbasin



This chapter only includes TMDLs for rivers and streams in the South Santiam Subbasin. These subbasin rivers and streams are tributary to the South Santiam River. The temperature analysis for the South Santiam River, from the mouth to River Mile (RM) 37.7 (Foster Reservoir), is included in the mainstem Willamette River TMDLs, see Chapter 4. All other subbasin TMDLs are included in Chapters 5 – 13.

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[1] The 303(d) list is a list of stream segments that do not meet water quality criteria.

Water Quality 303(d) Listed Waterbodies
OAR 340-042-0040(4)(a)

All current 303(d) listings for the South Santiam Subbasin are presented in Table 9.1.

Table 9.1 Name and location of listed South Santiam Subbasin waterbodies.

Waterbody Name	Listed River Mile	Parameter	Criteria	Season	TMDL
Beaver Creek	0 to 16	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Crabtree Creek	0 to 32.1	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Hamilton Creek	0 to 11.6	Temperature	Rearing: 17.8 C	Summer	Chapter 9
McDowell Creek	0 to 5.7	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Middle Santiam River	5.3 to 37.1	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Neal Creek	0 to 10	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Quartzville Creek	3.3 to 26.8	Temperature	Rearing: 17.8 C	Summer	Chapter 9
South Santiam River	0 to 25.9	Temperature	Rearing: 17.8 C	Summer	Chapter 4
South Santiam River	0 to 25.9	Temperature	Spawning: 12.8 C	September 15 - June 30	Chapter 4
South Santiam River	35.7 to 63.4	Temperature	Rearing: 17.8 C	Summer	Chapter 9
South Santiam River	35.7 to 63.4	Temperature	Spawning: 12.8 C	September 1 - June 30	Chapter 9
Sucker Slough	0 to 9.8	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Thomas Creek	0 to 16.2	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Thomas Creek	16.2 to 26.1	Temperature	Rearing: 17.8 C	Summer	Chapter 9
Wiley Creek	0 to 17.2	Temperature	Rearing: 17.8 C	Summer	Chapter 9

Water Quality Parameters Addressed

- In the South Santiam Subbasin chapter, temperature is the only parameter addressed with allocations.

- Bacteria has been addressed through a basin wide assessment of TMDLs developed for subbasins with streams listed as water quality limited for bacteria, specifically the Upper Willamette Subbasin, Middle Willamette Subbasin, and Lower Willamette Subbasin. Planning targets have been identified for urban and agricultural land in the South Santiam Subbasin where no streams have been listed. The appropriate use of planning targets is in water quality management planning. The ubiquitous nature of fecal bacteria suggests that water quality would benefit from implementation of these targeted reductions in the absence of documented violations. In general, targeted reductions for agricultural areas range from 66% to 83%, and reductions for urban areas range from 80% to 94%, relative to current concentrations. The details of this assessment and the planning targets are contained in the Allocation Section of Chapter 2, Willamette Basin Bacteria TMDL.

- Mercury is a parameter of concern throughout the Willamette Basin. A 27% reduction in mercury pollution is needed in the mainstem Willamette to remove fish consumption advisories. Pollutant load allocations are set for each sector but no effluent limits are specified at this time. Sources of mercury in the subbasin will be required to develop mercury reduction plans. Details of the mercury TMDL are included in Chapter 3, the Willamette Basin Mercury TMDL.

Who helped us

Many organizations assisted ODEQ in the development of this TMDL and data from many different sources were considered. ODEQ would like to acknowledge the assistance of the following organizations and agencies.

- South Santiam Watershed Council
- Oregon State University
- U.S. Bureau of Land Management (BLM)
- U.S. Forest Service (USFS)
- U.S. Geological Survey, Oregon District (USGS)
- Oregon Water Resources Department (WRD)

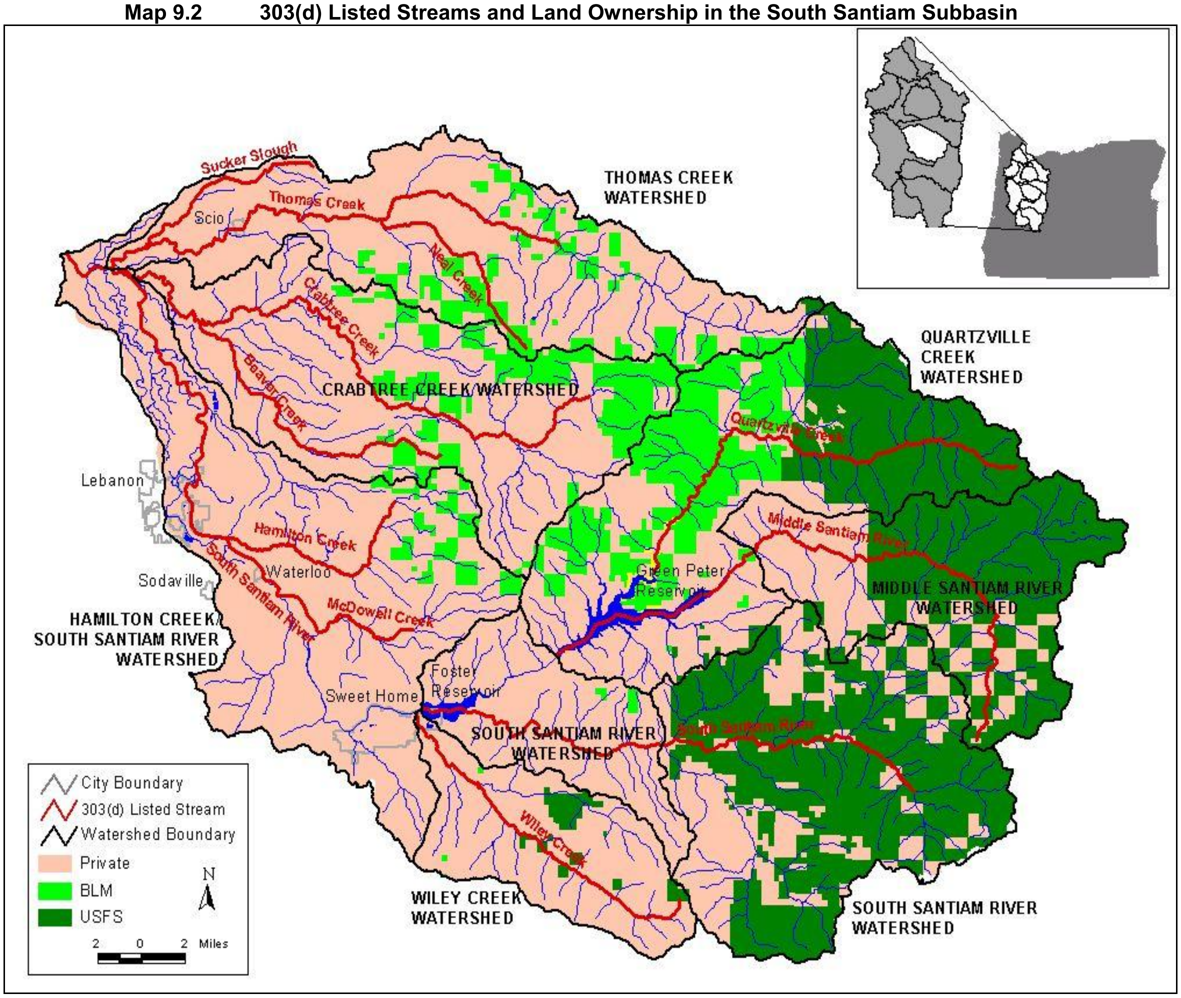
SUBBASIN OVERVIEW

The South Santiam Subbasin (Hydrologic Unit Code 17090006) is located in the eastern portion of the Willamette Basin and drains the Cascade foothills. The South Santiam River flows into the Santiam River just upstream of the City of Jefferson. The Subbasin's 1,041 square miles (666,237 acres) include the following eight watersheds:

- Crabtree Creek Watershed
- Hamilton Creek / South Santiam River Watershed
- Middle Santiam River Watershed
- Quartzville Creek Watershed
- South Santiam River Watershed, downstream of Canyon Creek
- South Santiam River Watershed, upstream of Canyon Creek
- Thomas Creek Watershed
- Wiley Creek Watershed

The subbasin's jurisdiction is within Linn County, and includes the Cities of Scio, Sweet Home, Waterloo, and portions of Lebanon and Sodaville, Map 9.2. The subbasin is primarily owned by private landowners, however federal and state ownership accounts for 30 to 40% of the total land use in the subbasin. There are scattered landholdings by the Bureau of Land Management (BLM) and USFS. The subbasin consists of forestry, agriculture and urban land uses.

Map 9.2 303(d) Listed Streams and Land Ownership in the South Santiam Subbasin



Watershed Descriptions

Crabtree Creek Watershed

The Crabtree Creek Watershed drains a 156 square mile (99,840 acres) area of the low gradient, rolling hills of the west slope of the Cascade Range. The watershed is dominated by private ownership. Forestry accounts for 72% of the land area, and consists of primarily privately owned forested land parcels. Agricultural land use is 27% of the watershed.

There are 12 CAFOs in the watershed as reported by the Oregon Department of Agriculture (ODA) in March 2003, consisting of 11 dairies and one mink operation. There are no NPDES permits in the watershed, however there is one general, minor permit issued to Roaring River Fish Hatchery that discharges to Roaring River.

Crabtree Creek Watershed has three major tributaries that contribute to its flow, Beaver Creek, Roaring River and Bald Peter Creek. Crabtree Creek flows into the South Santiam River at approximately RM 4. The watershed supports spring Chinook, winter steelhead and resident fisheries. There are no real-time flow gages in the Crabtree Creek Watershed.

Hamilton Creek / South Santiam River Watershed

The Hamilton Creek / South Santiam River Watershed drains a 186 square mile (119,040 acres) area of the low gradient, rolling hills of the west slope of the Cascade Range. The cities of Lebanon, Sweet Home, and Waterloo are located within this watershed. Forestry accounts for 58% of the land area, and consists of primarily privately owned forested land parcels. Agricultural land use is 32% of the watershed and the remaining 7% is urban. The watershed is dominated by private ownership.

There are six CAFOs in the watershed as reported by ODA in March 2003, consisting of three dairies, one mink operation, one horse lot, and one unidentified operation. There are four NPDES permits in the watershed; however they discharge directly to the South Santiam River and will be addressed in the mainstem Willamette Temperature document, Chapter 4. The 15 general permits in the watershed consist of a wash water facility, several stormwater drains, a boiler blow down, a gravel mining operation, and the South Santiam Fish Hatchery.

The watershed has four major tributaries that contribute to the Santiam River flow: McDowell Creek, Hamilton Creek, Ames Creek and Noble Creek. Hamilton Creek flows into the South Santiam River at approximately RM 21. McDowell Creek flows into the South Santiam River at approximately RM 28. The watershed supports fall Chinook, spring Chinook, summer steelhead, winter steelhead, and resident fisheries. There are no real-time flow gages on the Hamilton Creek / South Santiam River Watershed tributaries. However, several real-time flow gages are in operation on the South Santiam River downstream of Foster Reservoir.

Middle Santiam River Watershed

The Middle Santiam River Watershed drains a 104 square mile (66,560 acres) area of the west slope of the Cascade Range. Forestry accounts for 100% of the land use area. The watershed is split between private ownership and public ownership under the management of the Willamette National Forest. The Middle Santiam Wilderness is part of this watershed. There are no CAFOs or point sources in the watershed. The Middle Santiam River flows into Green Peter Reservoir. The flow in the Middle Santiam River is supplemented by Pyramid Creek. The watershed supports salmon and trout rearing and migration, as designated by the new temperature criteria, and resident fisheries. There are no real-time flow gages in the watershed.

Quartzville Creek Watershed

The Quartzville Creek Watershed drains a 171 square mile (109,440 acres) area of the west slope of the Cascade Range. Forestry is the predominant land use in the area. The watershed is dominated by public ownership under the management of the Willamette National Forest and the Bureau of Land Management

(BLM). However, one-third of the watershed is privately owned. There are no CAFOs or point sources in the watershed.

Quartzville Creek flows into Green Peter Reservoir, and has a road that parallels 20 miles of its 28 mile stream length. The flow in Quartzville Creek is supplemented by Canal Creek which drains the Albany mine area, which is the Historic Quartzville town site. The watershed supports salmon and trout rearing and migration, and resident fisheries. There is one real-time flow gage in the watershed, USGS flow gage #14185900, Quartzville Creek near Cascadia.

South Santiam River Watersheds

The South Santiam River Watershed consists of two drainages, both identified as the South Santiam River Watershed according to their hydrologic unit code identified by the USGS and will be described together to avoid confusion. The smaller drainage is downstream of Canyon Creek and is 57 square miles (36,480 acres) and includes Foster Reservoir. Foster Reservoir is located at river mile 37.7 of the South Santiam River. The larger upper South Santiam River Watershed drainage, upstream of Canyon Creek, is 159 square miles (101,760 acres). Forestry dominates the land use area of both of the watersheds. Half of the area is publicly owned under the management of the Willamette National Forest. Public ownership includes Cascadia State Park and the Menagerie Wilderness Area. The other half of the watershed is privately owned. There are no CAFOs or point sources in the drainage area.

The South Santiam flows into Foster Reservoir, and has a road that parallels 20 miles of the rivers 27 mile length. The flow in the South Santiam River above Foster Reservoir is supplemented by Canyon Creek, Moose Creek and Soda Fork South Santiam River. The watershed supports winter steelhead, spring Chinook, and resident fisheries. There is one real-time flow gage in the watershed, USGS flow gage #14187200, South Santiam River near Foster.

Thomas Creek Watershed

The Thomas Creek Watershed is 145 square miles (732,797 acres). The city of Scio is located within this watershed. Forestry dominates the land use area at approximately 73%. Agriculture supports 27% of the watershed. The watershed is dominated by private ownership, however, BLM owns approximately one-fifth of the watershed.

There are five CAFOs in the watershed, three dairies and two unidentified operations. There is one point source in the watershed, Scio STP a minor NPDES permitted facility that does not discharge from May 1 to October 31.

Thomas Creek flows into the South Santiam River at approximately RM 3. The flow in Thomas Creek is supplemented by its major tributary, Neal Creek. The watershed supports spring Chinook,winter steelhead, and resident fisheries. There are two real-time flow gages in the watershed, USGS flow gage #14188800, Thomas Creek near Scio, and USGS flow gage #14188850, Thomas Creek near Crabtree.

Wiley Creek Watershed

The Wiley Creek Watershed is 63 square miles (40,320 acres). The eastern portion of the city of Sweet Home is located within this watershed. Forestry dominates the land use area. The watershed is dominated by private ownership, however approximately 15% of the watershed is owned by the USFS.

There are no CAFOs in the watershed. There is one NPDES minor industrial point source in the watershed, Foster Plywood discharging to Wiley Creek, and there is one minor NPDES domestic facility, Brownsville STP discharging to South Santiam River. Both NPDES facilities do not discharge during May 1 to October 31. There are two general storm water permitted facilities in the watershed.

Wiley Creek flows into the South Santiam River just downstream of Foster Reservoir. The watershed supports spring Chinook, summer steelhead, winter steelhead, and resident fisheries. There is one real-time flow gage in the watershed, USGS flow gage #14187000, Wiley Creek near Foster.

SOUTH SANTIAM TEMPERATURE TMDL

The temperature TMDL for the South Santiam Subbasin includes tributaries to the South Santiam River within HUC 17090006. As per Oregon Administrative Rule (OAR) 340-042-0040 required components of a TMDL are listed in Table 9.2.

Table 9.2 South Santiam Subbasin Temperature TMDL Components.

Waterbodies **OAR 340-042-0040(4)(a)**	Perennial and/or fish bearing, as identified in OAR 340-041- 0340; Figures 340A & 340B, streams in the South Santiam Subbasin, HUCs 170900601, 170900602, 170900603, 170900604, 170900605, 170900606, 170900607 and 170900608.
Pollutant Identification **OAR 340-042-0040(4)(b)**	*<u>Pollutants</u>:* Human caused temperature increases from (1) solar radiation loading and (2) warm water discharge to surface waters
Beneficial Uses **OAR 340-042-0040(4)(c)**	Salmonid fish spawning and rearing, anadromous fish passage, resident fish and aquatic life are the most sensitive beneficial uses in the South Santiam Subbasin.
Target Criteria Identification **OAR 340-042-0040(4)(c)** ***CWA §303(d)(1)*** **OAR 340-041-0028(4)(f)** **OAR 340-041-0028(4)(a)** **OAR 340-041-0028(4)(b)** **OAR 340-041-0028(4)(c)** ***OAR* 340-041-0028(8)** **OAR 340-041 0028(12)(b)(B)**	OAR 340-041-0028 provides numeric and narrative temperature criteria. Maps and tables provided in OAR 340-041-0101 to 0340 specify where and when the criteria apply. 12.0°C during times and at locations of bull trout spawning and juvenile rearing use. 13.0°C during times and at locations of salmon and steelhead spawning. 16.0°C during times and at locations of core cold water habitat identification. 18.0°C during times and at locations of salmon and trout rearing and migration. Natural Conditions Criteria: Where the department determines that the natural thermal potential temperature of all or a portion of a water body exceeds the biologically-based criteria in section 4 the natural thermal potential temperatures supersede the biologically-based criteria and are deemed the applicable criteria for that water body. Maps and tables provided in OAR 340-041-0101 to 0340 specify where and when the criteria apply. Following a temperature TMDL or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact.
Existing Sources **OAR 340-042-0040(4)(f)** ***CWA §303(d)(1)***	Nonpoint source solar loading due to a lack of riparian vegetation from forestry, agriculture, rural residential, and urban activities. Point source discharge of warm water to surface water.
Seasonal Variation **OAR 340-042-0040(4)(j)** ***CWA §303(d)(1)***	Peak temperatures typically occur in mid-July through mid-August and often exceed the salmon and trout rearing and migration criterion. Temperatures are much cooler late summer through late spring but occasionally exceed the spawning criterion.
TMDL **Loading Capacity and Allocations** **OAR 340-042-0040(4)(d)** **OAR 340-042-0040(4)(e)** **OAR 340-042-0040(4)(g)** **OAR 340-042-0040(4)(h)** ***40 CFR 130.2(f)*** ***40 CFR 130.2(g)*** ***40 CFR 130.2(h)***	*<u>Loading Capacity</u>:* OAR 340-041-0028 (12)(b)(B) states that no more than a 0.3°C increase in stream temperature above the applicable biological criteria or the natural condition criteria as a result of human activities is allowable. This condition is achieved when the cumulative effect of all point and nonpoint sources results in no greater than a 0.3 °C (0.5 °F) increase at the point of maximum impact. Loading capacity is the heat load that corresponds to the applicable numeric criteria plus the small increase in temperature of 0.3°C provided with the human use allowance. *<u>Excess Load</u>*: The difference between the actual pollutant load and the loading capacity of the waterbody. In these temperature TMDLs excess load is the difference between heat loads that meet applicable temperature criteria plus the human use allowance and current heat loads from background, nonpoint source and point source loads. *<u>Wasteload Allocations (NPDES Point Sources)</u>*: Allowable heat load based on achieving no greater than a 0.3°C temperature increase at the point of maximum impact. This is achieved by limiting stream temperature increases from individual point sources to 0.075ºC. This may also be expressed as a limitation of 0.3ºC increase in 25% of the 7Q10 stream flow. Where multiple point sources discharge to a single receiving stream the accumulated heat increase for point sources is limited to 0.2˚C. *<u>Load Allocations (Nonpoint Sources)</u>*: Background solar radiation loading based on system potential vegetation near the stream. An additional heat load equal to 0.05°C temperature increase at the point of maximum impact is available but is not explicitly allocated to individual sources. • Thomas Creek background solar radiation loading based on system potential vegetation is 10.11×10^8 kcal/day. • Crabtree Creek background solar radiation loading based on system potential vegetation is 13.2×10^8 kcal/day.

Surrogate Measures **OAR 340-042-0040(5)(b)** ***40 CFR 130.2(i)***	*Translates Nonpoint Source Load Allocations* Effective shade targets translate riparian vegetation objectives into the nonpoint source solar radiation loading capacity. These targets are based on vegetation communities appropriate for each geomorphic unit in the subbasin.
Margins of Safety **OAR 340-042-0040(4)(i)** ***CWA §303(d)(1)***	*Margins of Safety* are demonstrated in critical condition assumptions for point source load calculations and are inherent in the methodology for determining nonpoint source loads.
Reserve Capacity **OAR 340-042-0040(4)(k)**	Allocation for increases in pollutant loads for future growth from new or expanded sources. Reserve capacity will be a percentage of the 0.3˚C human use allowance (HUA). The HUA will be divided among various sources. When point sources are present reserve capacity will be 0.05˚C, 17% of the HUA. Where there are no point sources in a subbasin, or less than the allowed 0.2˚C is used by point source discharges, the remainder is allocated to reserve capacity.
Water Quality Management Plan **OAR 340-042-0040(4)(l)**	The Water Quality Management Plan (WQMP) provides the framework of management strategies to attain and maintain water quality standards. The WQMP is designed to complement the detailed plans and analyses provided in specific implementation plans. See Chapter 14.
Standards Attainment & Reasonable Assurance **OAR 340-042-0040(4)(l)(e) & (j)**	Implementation of pollutant load reductions and limitations in the point source and non point source sectors will result in water quality standards attainment. Standards Attainment and Reasonable Assurance are addressed in the WQMP, Chapter 14.

Waterbodies Listed for Temperature

OAR 340-042-0040(4)(a)

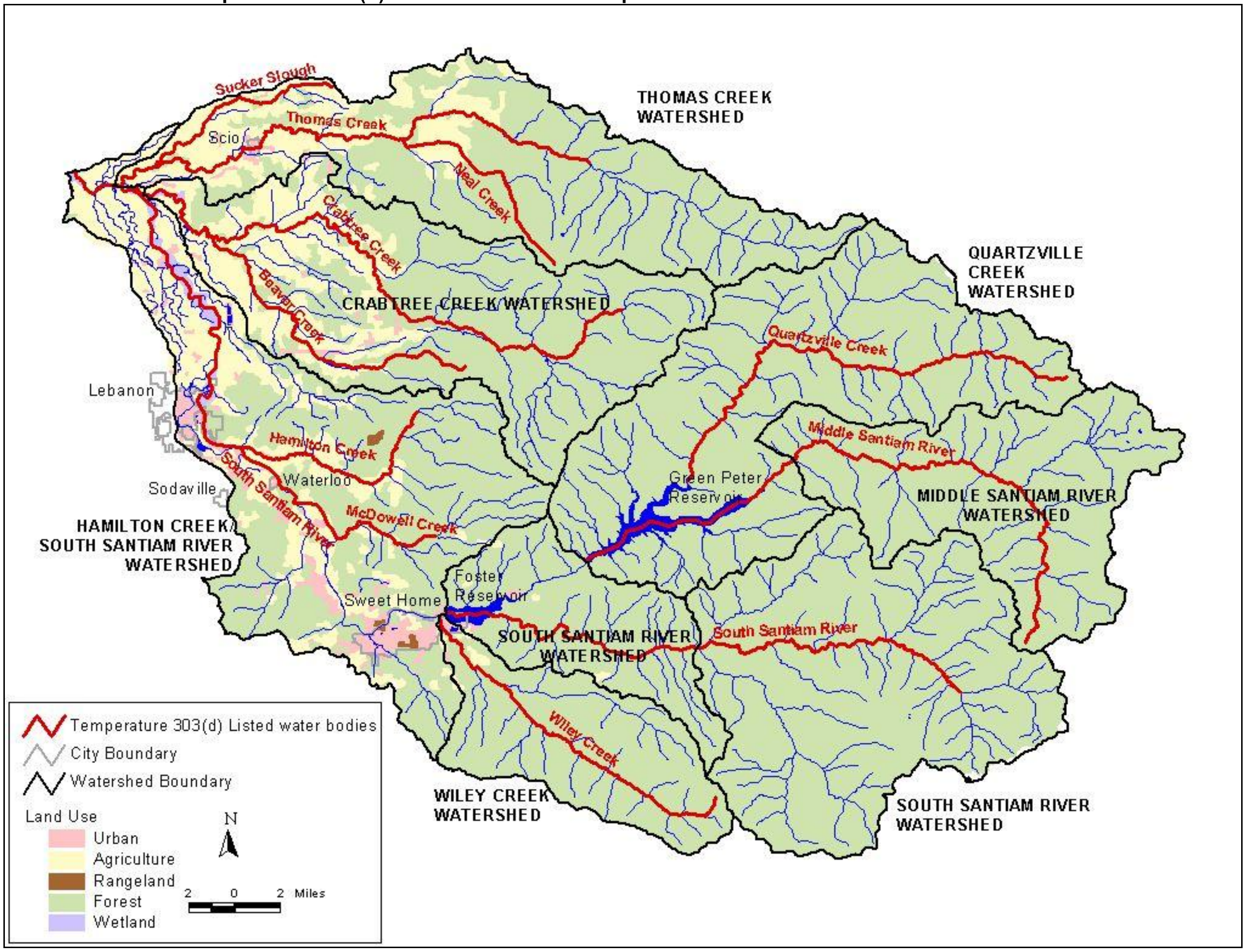
The South Santiam Subbasin has 11 stream segments on the 303(d) list for exceeding the water temperature criteria. Ten of the stream segments listed exceed the temperature criteria during the summer, July through September: Beaver Creek, Crabtree Creek, Hamilton Creek, McDowell Creek, Middle Santiam River, Neal Creek, Quartzville Creek, Sucker Slough, Thomas Creek and Wiley Creek, Table 9.3 and Map 9.3. The South Santiam River above Foster Dam (RM 35.7 to RM 63.4) is listed year round for exceeding the temperature criteria. The South Santiam River from RM 0 to RM 25.9 will be addressed in Chapter 4 of this document.

Stream segments were listed under the previous temperature standard because they exceeded the temperature criterion of 17.8°C (64°F) for salmonid migration and rearing, Table 9.3. However, new temperature standards were adopted by the Environmental Quality Commission in December 2003 and approved by USEPA in March 2004. The new temperature criterion for salmon and trout rearing and migration is 18.0°C (64.4°F). Temperature data for the streams listed in Table 9.3 indicates that these streams exceed the recently adopted numeric criterion.

Table 9.3 South Santiam Subbasin 303(d) Temperature Listed Stream Segments

Waterbody Name	Listed River Mile	Parameter	Criteria	Season
Beaver Creek	0 to 16	Temperature	Rearing: 17.8 C	Summer
Crabtree Creek	0 to 32.1	Temperature	Rearing: 17.8 C	Summer
Hamilton Creek	0 to 11.6	Temperature	Rearing: 17.8 C	Summer
McDowell Creek	0 to 5.7	Temperature	Rearing: 17.8 C	Summer
Middle Santiam River	5.3 to 37.1	Temperature	Rearing: 17.8 C	Summer
Neal Creek	0 to 10	Temperature	Rearing: 17.8 C	Summer
Quartzville Creek	3.3 to 26.8	Temperature	Rearing: 17.8 C	Summer
South Santiam River	35.7 to 63.4	Temperature	Rearing: 17.8 C	Summer
South Santiam River	35.7 to 63.4	Temperature	Spawning: 12.8 C	September 1 - June 30
Sucker Slough	0 to 9.8	Temperature	Rearing: 17.8 C	Summer
Thomas Creek	0 to 16.2	Temperature	Rearing: 17.8 C	Summer
Thomas Creek	16.2 to 26.1	Temperature	Rearing: 17.8 C	Summer
Wiley Creek	0 to 17.2	Temperature	Rearing: 17.8 C	Summer

Map 9.3 303(d) Listed Streams for Temperature in the South Santiam Subbasin



Pollutant Identification

OAR 340-042-0040(4)(b)

ODEQ must establish a TMDL for any waterbody designated on the 303(d) list as exceeding water quality criteria. Although temperature criteria are designed to protect beneficial uses from excessive water temperature, the pollutant of concern is heat energy. Water temperature change is an expression of heat energy exchange per unit of volume:

$$\Delta Temperature \propto \frac{\Delta Heat\ Energy}{Volume}$$

Stream temperatures are affected by natural and human caused sources of heating. Disturbance processes such as wildfire, flood, and insect infestation influence the presence, height and density of riparian vegetation which in turn determines the amount of solar radiation reaching the stream. Such processes are recognized and incorporated as a natural condition in the TMDL. This temperature TMDL does address stream heating caused by human activities that affect characteristics of riparian vegetation in addition to point sources that discharge heat directly into surface waters in the South Santiam Subbasin.

Beneficial Use Identification
OAR 340-042-0040(4)(c)

Numeric and narrative water quality criteria are applied to protect the most sensitive beneficial uses. The most sensitive beneficial uses to temperature in the South Santiam Subbasin are:

- Resident fish and aquatic life
- Salmonid spawning, rearing and migration
- Anadromous fish passage

At a minimum, beneficial uses are considered attainable wherever feasible or wherever attained historically.

Salmonid Stream Temperature Requirements

This temperature TMDL is focused on the protection of cold water salmonids, specifically steelhead and salmon. In general, there are three levels of thermally induced fish mortality. If stream temperatures become greater than 32 °C (>90°F), fish die almost instantly due to denaturing of critical enzyme systems in their bodies (Hogan, 1970). This level is termed *instantaneous lethal limit.* The second level is termed *incipient lethal limit* and can cause fish mortality in hours to days when temperatures are in the 21°C to 25°C (70°F to 77°F) range. The time period to death depends on the acclimation and life-stage of the fish. The cause of death is from the breakdown of physiological regulation, such as respiration and circulation, which are vital to fish health (Heath and Hughes, 1973). The third level is the most common and widespread cause of thermally induced fish mortality, termed *indirect or sub-lethal limit* and can occur weeks to months after the onset of elevated stream temperatures of 17.8°C to 23°C (64°F to 74°F). The cause of death is from interactive effects such as: decreased or lack of metabolic energy for feeding, growth, and reproductive behavior; increased exposure to pathogens (viruses, bacteria and fungus); decreased food supply because the macroinvertebrate populations are also impaired by high stream temperature; and increased competition from warm water tolerant species. Table 9.4 summarizes the modes of cold water fish mortality.

Table 9.4 Thermally Induced Cold Water Fish Mortality Modes (Brett, 1952; Bell, 1986, Hokanson et al., 1977)

Modes of Thermally Induced Fish Mortality	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 32°C (> 90°F)	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	21°C - 25°C (70°F - 77°F)	Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	17.8°C - 23°C (64°F - 74°F)	Weeks to Months

Target Criteria Identification
OAR 340-041-0028(4)(c), OAR 340-041-0028(4)(d),OAR 340-041-0028(9)
CWA 303(d)(1)

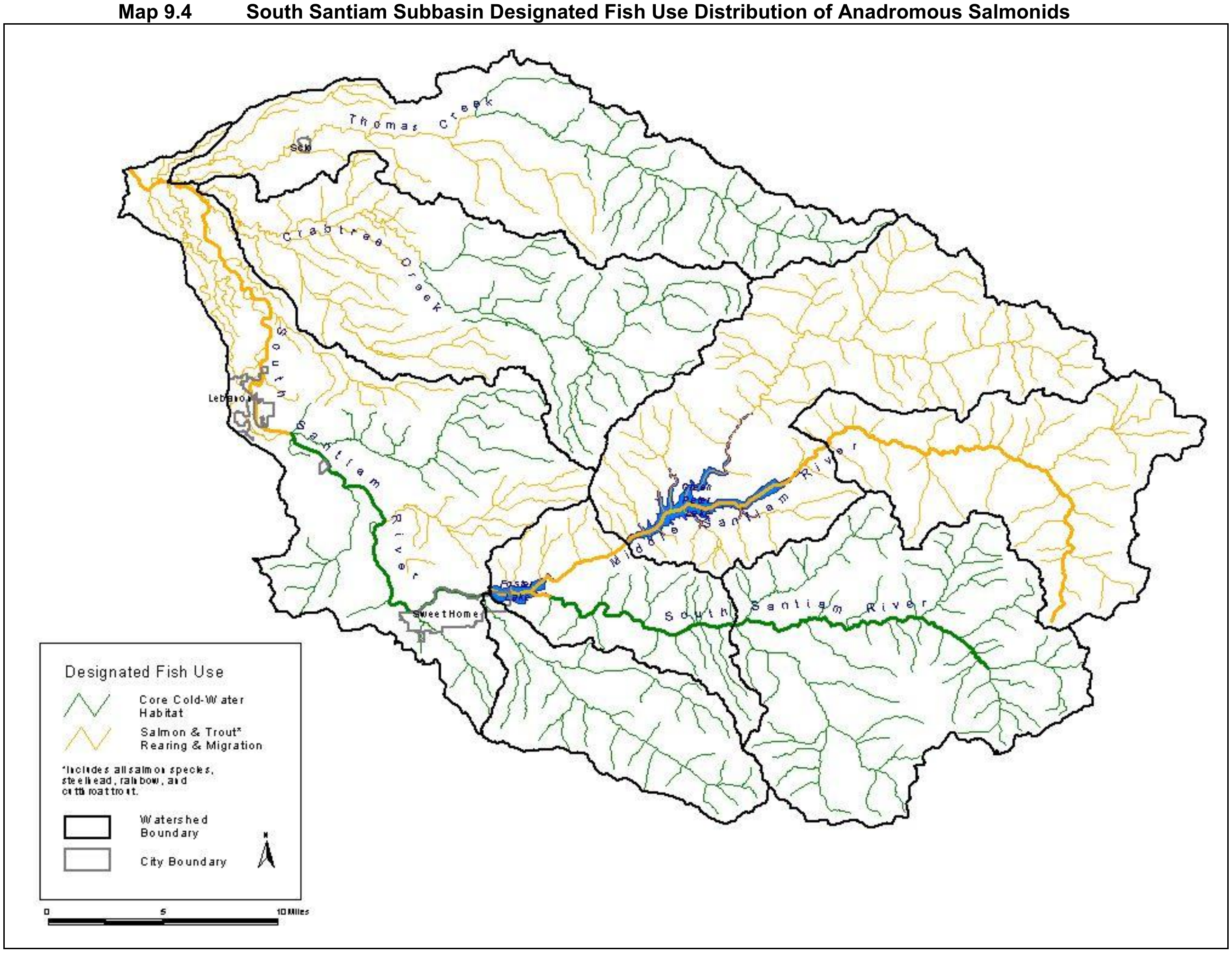
Oregon's water quality criteria for temperature are designed to protect beneficial uses, such as cold-water salmon and trout species, based on specific salmonid life stages. The temperature criteria include both narrative and numeric criteria. Table 9.5 lists the temperature criteria that are applicable to the South Santiam Subbasin. Maps 9.4 and 9.5 illustrate designated subbasin fish use and salmonid spawning use. The maps indicate where the salmonid spawning through fry emergence criterion, core cold water habitat criterion, and salmonid rearing and migration criterion apply. For subbasin waters where fisheries uses are not identified, the applicable criteria are the same as the nearest downstream waterbody that is identified in fish use maps. Willamette Basin fish use and spawning use maps are available for electronic download on ODEQs website at:
http://www.deq.state.or.us/wq/standards/FishUseMapsFinal/FFigure340A_Willamette.pdf and
http://www.deq.state.or.us/wq/standards/FishUseMapsFinal/FFigure340B_Willamette.pdf

Table 9.5 Oregon's Biologically Based Temperature Criteria.

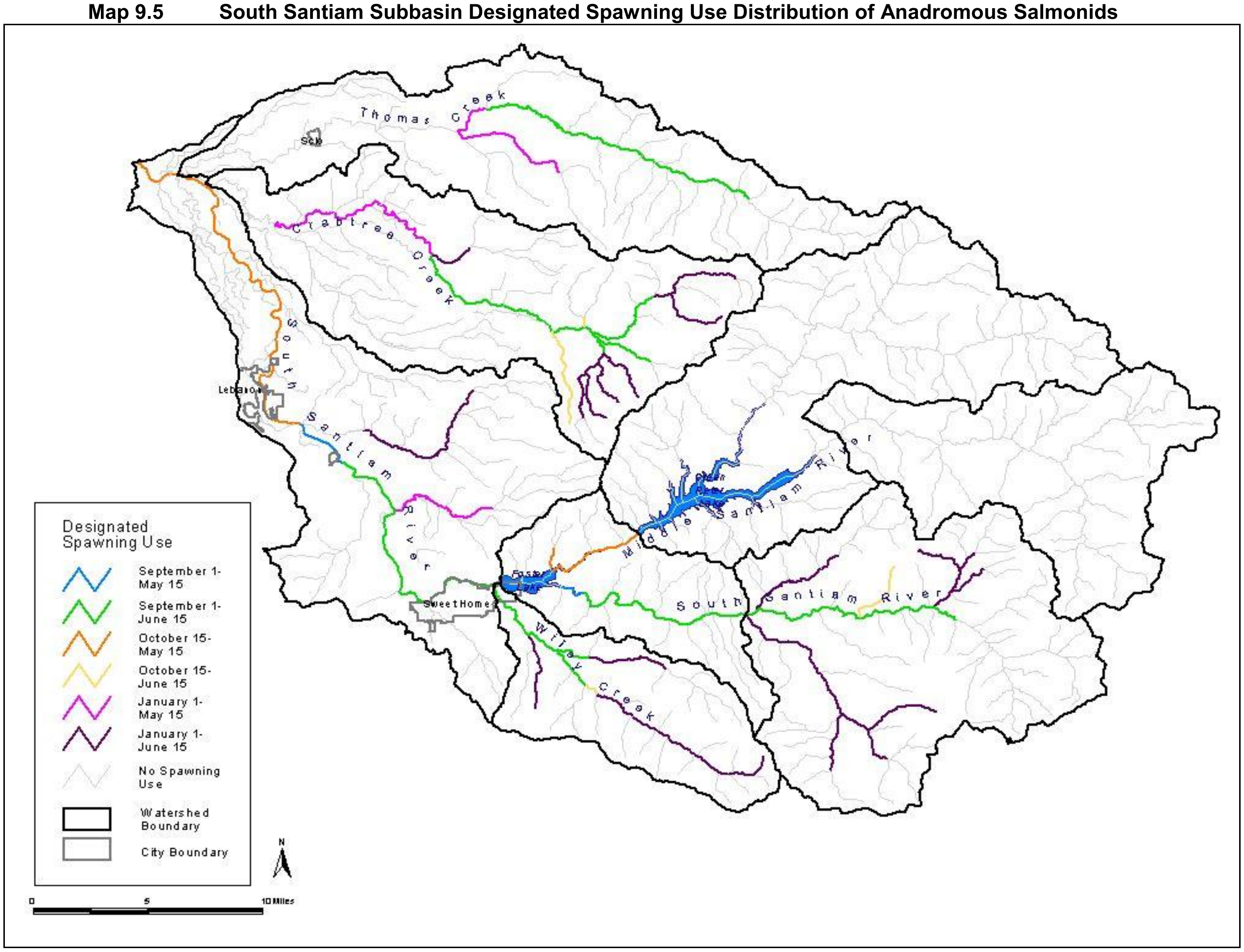
Beneficial Use	Temperature Criteria
Salmon and Steelhead Spawning	∗13.0°C (55.4°F)
Core Cold Water Habitat Identification	*16.0°C (60.8°F)
Salmon and Trout Rearing and Migration	∗18.0 °C (64.4 °F)

∗ Stream temperature is calculated using the average of seven consecutive daily maximum temperatures on a rolling basis (7-day calculation).

Map 9.4 South Santiam Subbasin Designated Fish Use Distribution of Anadromous Salmonids



Map 9.5 South Santiam Subbasin Designated Spawning Use Distribution of Anadromous Salmonids



The narrative criteria that apply to the South Santiam Subbasin describe the conditions under which biological numeric criteria may be superseded. The criteria acknowledge that in some instances the biologically based numeric criteria may not be achieved because the natural thermal potential of the stream temperature is warmer than the biologically based numeric criteria. A stream that is free from anthropogenic influence is considered to be at natural thermal potential. When it exceeds the appropriate biologically based criterion, the natural thermal potential becomes the natural condition numeric temperature criterion for that specific stream or stream segment. This often occurs in low elevation streams in the basin during summer months.

Following a temperature TMDL or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact.

A more extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers* (ODEQ, 1995) and in *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (USEPA, 2003).

Existing Heat Sources

OAR 340-042-0040(4)(f), CWA §303(d)(1)

Sources of heat pollution include nonpoint sources and point sources. Nonpoint sources are generally more diffuse in nature and cannot be traced back to a particular location. These sources are defined below in terms of land use. Dams and reservoir operations are also included as nonpoint sources of pollution although their effects on water quality are generally more identifiable than dispersed land use activities. Point sources are individual facilities that discharge a pollutant from a defined conveyance (e.g. an outfall pipe) and are regulated by permit.

Nonpoint Sources of Heat

Land use activities. Riparian vegetation, stream morphology, hydrology (including groundwater interactions), climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by land use activities. Disturbance or removal of vegetation near a stream reduces stream surface shading because of decreased vegetation height, width and density. This results in greater amount of solar radiation reaching the stream surface.

Riparian vegetation also influences channel morphology. Vegetation supports stream banks during erosive, high flow events and slows floodwaters and promotes sediment deposition when floodwaters overtop the banks. Loss or disturbance of riparian vegetation may precede lateral stream bank erosion and channel widening. This decreases the effectiveness of remaining vegetation to shade the stream and increases the stream surface area exposed to heat exchange processes, particularly solar radiation.

Dam and Reservoir operations. Dams and reservoir operations affect stream temperature through the modification of flow regimes and through the delivery of heat stored within the system. Flow augmentation during the low flow periods of the year may be beneficial to stream segments below the dam as higher flows increase stream volume and therefore the loading capacity of the segment. Also, higher volumes correspond to greater stream velocities and shorter travel times through stream reaches exposed to solar radiation. However, operations that divert flows from natural channels during low flow periods may substantially diminish the loading capacity of the stream while also increasing solar loading to the stream because of lower velocities and greater travel times through exposed reaches.

The release of water from reservoirs may also increase down stream temperatures as the heat held by the impounded water is also released. The timing, duration and magnitude of such impacts are dependent upon reservoir characteristics such as surface area, depth, and whether water is released from the bottom of the reservoir or selectively withdrawn from various depths.

There are two reservoirs in the South Santiam Subbasin, Foster Reservoir and Green Peter Reservoir, both impacting the mainstem South Santiam River. A discussion of the impacts of these reservoirs on the South Santiam River is discussed in Chapter 4.

Point Sources of Heat

Point source discharges play a limited role in stream heating in the streams of the South Santiam Subbasin. There are six individual NPDES permitted sources in the South Santiam Subbasin, four sources discharge directly into the South Santiam River and are addressed in the mainstem Willamette TMDL discussed in Chapter 4. The remaining two individual NPDES point sources consist of the City of Scio STP, a minor domestic NPDES source that discharges to Thomas Creek, and Foster Plywood, a minor industrial NPDES source that discharges to Wiley Creek, Map 9.6 and Table 9.6. Neither source discharges during May 1 to October 31, the critical period for salmonid spawning and rearing, and therefore will not be given a temperature wasteload allocation. In addition to the NPDES point sources identified above, there are 22 general NPDES permits in the subbasin including the Roaring River Fish Hatchery. The hatchery is a point source discharging to Roaring River, a tributary to Crabtree Creek; it is anticipated to discontinue operations in the near future. There are also a number of stormwater permits for facilities located within the South Santiam Subbasin. Stormwater sources are not considered to have reasonable potential to contribute to exceedances of numeric temperature criteria.

Map 9.6 South Santiam Subbasin NPDES Permit Locations. April, 2003.

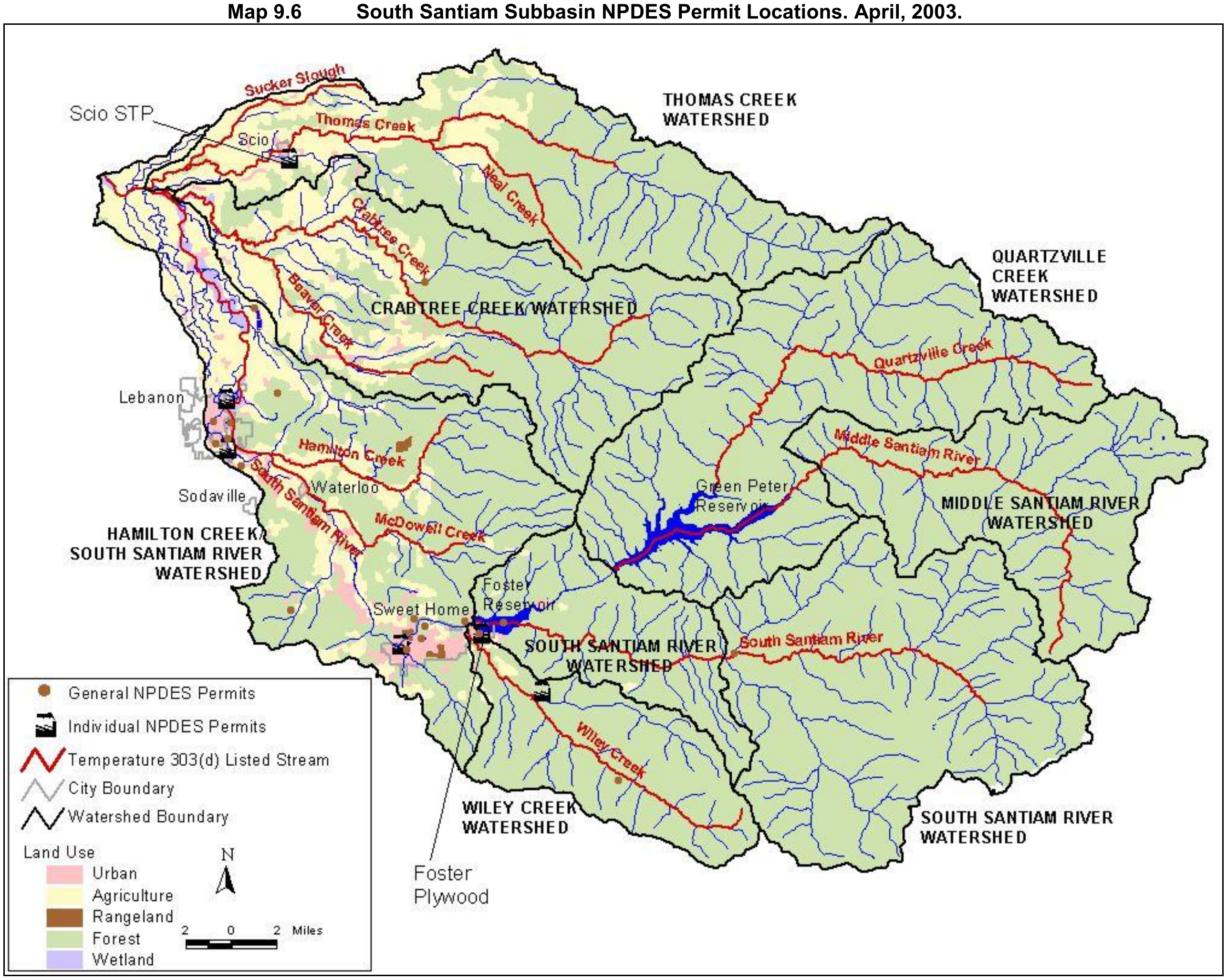


Table 9.6 Individual NPDES facilities in the South Santiam Subbasin, which do not discharge to the mainstem South Santiam River. April, 2003.

Facility Name	Permit Type	Permit Description	Receiving Stream	River Mile	Type of Discharge	Season of Discharge
SCIO STP	NPDES-DOM-Db	Sewage - less than 1 MGD with lagoons	Thomas Creek	8.0	Wastewater	FWS
FOSTER PLYWOOD	NPDES-IW-O	Industrial Wastewater; NPDES non-process wastewater NEC	Wiley Creek	0.9	Process Water	FWS

FWS = Fall-Winter-Spring; approximately October through May
NEC = Not Elsewhere Classified

Temperature TMDL Approach Summary

South Santiam Subbasin stream temperature TMDLs were developed at the watershed scale. These TMDLs include all surface waters that affect the temperatures of 303(d) listed water bodies because stream temperature is affected by heat loads from upstream as well as local sources. Point and nonpoint sources of heat may not cause an increase in temperature of more than the human use allowance (0.3˚C) when fully mixed with a stream and at the point of maximum impact. For the purposes of Willamette Basin TMDLs, the human use allowance has been divided among various sources using a framework established by DEQ with input from the Willamette TMDL Council. The framework allocates to point sources heat loads that yield a cumulative increase in stream temperature of no more than 0.2˚C. The framework allocates nonpoint sources an increase in temperatures of 0.05˚C and a heat load equivalent to 0.05˚C is held as reserve capacity. Where less than the 0.2˚C cumulative increase in temperature is actually used by point source discharges, the remainder is allocated to reserve capacity. The actual allocation of heat within the human use allowance is not specified in the water quality standards and this framework is used simply as guidance for implementation of the TMDL.

Point Source Approach. Allocations or permit limits are developed for individual point source discharges that ensure the combined increase in temperature for all discharges does not exceed 0.2˚C at the point of maximum impact. Wasteload allocations for individual point sources are generally based on a quarter of the human use allowance and yield less than a 0.08ºC increase in temperature at the point of maximum impact. Individual waste load allocations may be greater than 0.08ºC based on an analysis of site specific needs provided the overall point source allocation is within the established human use allowance framework. The specific methods and equations used to develop wasteload allocations are contained in the Allocation section of this chapter, below.

Nonpoint Source Approach. Removal or disturbance of riparian vegetation is the primary nonpoint source activity with respect to stream temperatures in the subbasin. The temperature model Heat Source was used to calculate load allocations. Surrogate measures are used to represent nonpoint source heat loads. While heat from solar radiation in excess of natural background rates is considered the pollutant, the surrogate measure is effective shade. Effective shade targets, through the use of shade curves can be translated into site-specific load allocations such as Langleys per day. Both shade curves and system potential vegetation objectives were developed for the fifteen geomorphic units and upland forest areas in the South Santiam Subbasin.

Temperature TMDL Analytical Methods Overview

Load capacity is the assimilative capacity of each stream when anthropogenic sources of heat warm the stream no more than 0.3ºC above its natural thermal potential. Natural thermal potential is realized when point sources discharges of heat are eliminated and vegetation near the stream is undisturbed by management activities. Small additional heat load allocations can be made once these conditions are identified. Wasteload allocations for individual point sources are based on a change in river temperature at the point of maximum impact. These allocations are expressed in energy units such as kilocalories per day. Load allocations for nonpoint sources for Thomas and Crabtree Creeks are based on kilocalories per day, and the surrogate measure of percent effective shade.

Development of stream temperature TMDLs requires the identification of load capacity for each impaired stream. This often demands extensive data collection to support the development of detailed and complex models that are in turn used to simulate system responses to changes in pollutant loads. However, in many stream systems in the South Santiam Subbasin the primary sources of anthropogenic heat are land use activities that affect riparian and near-stream vegetation. Identification of load capacity in these systems first requires determination of stream shade conditions when these disturbances of vegetation are eliminated. This drives the need to determine system potential vegetation and its shade producing characteristics.

System potential vegetation is vegetation that can grow and reproduce at a near-stream site given climate, elevation, soil properties, plant community requirements and hydrologic processes (see Appendix C; "Near-Stream Land Cover" for detailed information). System potential vegetation is an estimate of the riparian condition where land use activities that cause stream warming are minimized. It is not intended to be an estimate of pre-settlement conditions, but is an important element in the determination of the natural thermal potential of a stream. In the absence of significant point sources of heat or stream flow modification, system potential vegetation is the basis for identification of natural thermal potential temperatures. These natural thermal potential temperatures serve as the natural conditions temperature criterion in many low elevation streams throughout the Willamette Basin.

The Oregon Administrative Rule for temperature has defined both natural conditions and natural thermal potential.

- OAR 340-041-0002(38) states:
  "Natural conditions" means conditions or circumstances affecting the physical, chemical, or biological integrity of a water of the State that are not influenced by past or present anthropogenic activities.

Disturbances from wildfire, floods, earthquakes, volcanic or geothermal activity, wind, insect infestation, diseased vegetation are considered natural conditions.

- OAR 340-041-0002(39) states:
  "*Natural Thermal Potential" means 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.*

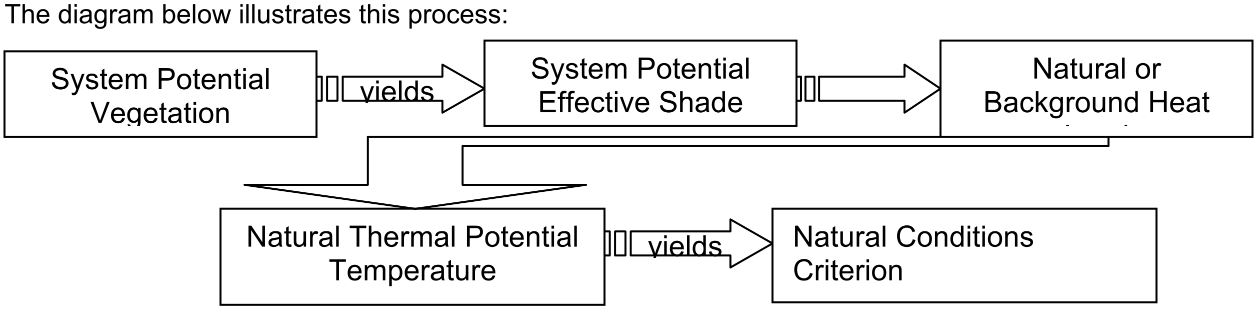
South Santiam Subbasin temperature TMDLs are based on the identification of system potential vegetation for each impaired waterbody and the calculation of the amount of shade provided by that vegetation to the stream. System potential vegetation in this analysis does allow for some level of natural disturbance such as fire and this is reflected as smaller tree heights and lower canopy densities in the calculation of shade levels. Put another way, mature vegetation was not used to simulate target conditions throughout the subbasin.

Effective shade is the percent of daily solar radiation that is blocked by vegetation and topography. System potential vegetation characteristics are used to estimate effective shade for each riparian community. These estimated effective shade values are often referred to as system potential effective shade when in the absence of human disturbance.

Solar radiation is a function of regional and local characteristics and is a factor in determining water temperature in the absence of significant point source influences. Regional factors such as latitude and topography determine potential solar radiation loading whereas local factors such as stream aspect, stream width and streamside vegetation characteristics determine actual solar radiation loading to the stream. Streamside vegetation characteristics that determine effective shade include vegetation height, canopy density, overhang, setback or distance from the edge of the stream, and the width of the riparian buffer. Mature, well-stocked riparian stands generally provide more effective shade to a stream than sparsely stocked riparian stands or stands of early successional plant communities. For more information on system potential vegetation refer to Appendix C, "Potential Near-Stream Land Cover for Willamette Basin".

Effective shade is a surrogate measure used for development of temperature load allocations. The use of effective shade targets alone will not support calculation of natural thermal potential stream temperatures. Extensive modeling is required to describe heat and water movement through the stream system and support the estimation of stream temperatures. Stream temperature estimation at system potential vegetation is calculated using the Heat Source Model. The Heat Source Model version 6.5 was used to calculate stream temperatures and effective shade at system potential vegetation. A description of the Heat Source model, model calibration statistics, and overview of the analytical analysis are described in Appendix C. An overview of Heat Source is also found on-line: http://www.heatsource.info/ Effective shade targets will allow for the calculation of the amount of solar loading reaching the stream and perhaps most importantly shade targets translate non-point source load allocations into site specific vegetation targets for land owners and managers.

The diagram below illustrates this process:



Stream temperature analysis discussed in this chapter is limited to stream systems in the South Santiam Subbasin. The water quality restoration strategies identified are applicable to all streams in the subbasin. Application of these strategies contributes to the basin-scale effort to restore and protect cooler water temperatures in other Willamette River tributaries. This broad scale application to all tributaries is an important element in the protection of coldwater aquatic life in the Willamette Basin. Although these streams are not likely to individually affect temperatures in the Willamette River, collectively they provide important localized sources of cool water and temporary thermal refugia for resident or migrating coldwater fish.

Seasonal Variation
OAR 340-042-0040(4)(j), CWA 303(d)(1)

Streams in the South Santiam Subbasin exceed biologically based rearing criteria starting in late spring and through late summer. Maximum temperatures typically occurred in late July and early August, Figure 9.1. Long-term temperature recorders deployed by ODEQ, BLM, and USGS indicate that summer stream temperatures exceed the 18.0ºC (64.4ºF) migration and rearing, 16.0ºC (60.8ºF) core cold water habitat, and 13.0ºC (55.4ºF) salmon and steelhead spawning criteria. Temperatures in South Santiam River tributary streams were commonly above the criterion during summer months. Temperatures in Thomas and Crabtree Creeks were commonly in the 24.0°-26.0°C (75.2°-78.8°F) range during summer. Streams exceeding the temperature criteria include Beaver Creek, Crabtree Creek, Hamilton Creek, McDowell Creek, Middle Santiam River, Neal Creek, Quartzville Creek, and South Santiam River above Foster Dam, Sucker Slough, Thomas Creek and Wiley Creek.

During the spring of 2000, ODEQ coordinated and led a temperature data collection field exercise in the South Santiam Subbasin with the Bureau of Land Management (BLM) Salem Division. The purpose of this field exercise was to train BLM field staff in the proper ODEQ temperature TMDL field collection methods such as in-stream temperature thermister placement, riparian vegetation characterization, channel characterization, and flow monitoring. In early June 2000, ODEQ and BLM placed temperature thermisters in-stream at various locations throughout the South Santiam Subbasin. ODEQ placed 37 and BLM placed 31 in-stream temperature thermisters, Map 9.7. The longitudinal profile of the seven day moving maximum for Thomas Creek, Crabtree Creek, Hamilton Creek, and McDowell Creek are shown in Figure 9.1. Thermisters were removed from the stream before stream flow conditions became hazardous, in late August 2000. During the last week of July, 2000, ODEQ and BLM staff conducted field sampling exercises to record instantaneous flow, characterize the stream channel, take an audit of in-stream temperatures, and to characterize the riparian vegetation. Digital photos and a Geographical Positioning System (GPS) determined latitude and longitude were recorded at each temperature monitoring location. USGS real-time flow gage information was also recorded when available, specifically for Heat Source hydrology development. During August 1st to August 3rd,2000 ODEQ contracted with Watershed Sciences, to collect and analyze Thermal Infra-Red (TIR) radiometry and visible video imagery for select tributaries in the Santiam River Basin. TIR for Thomas Creek, Crabtree Creek, and Hamilton Creek are shown in Figures 9.2, 9.3, 9.4, and 9.5. Data collection was timed to capture daily maximum stream temperatures, which typically occur between 14:00 and 18:00 hours (2:00 pm and 6:00 pm).

Map 9.7 Temperature Monitoring Locations in the South Santiam Subbasin

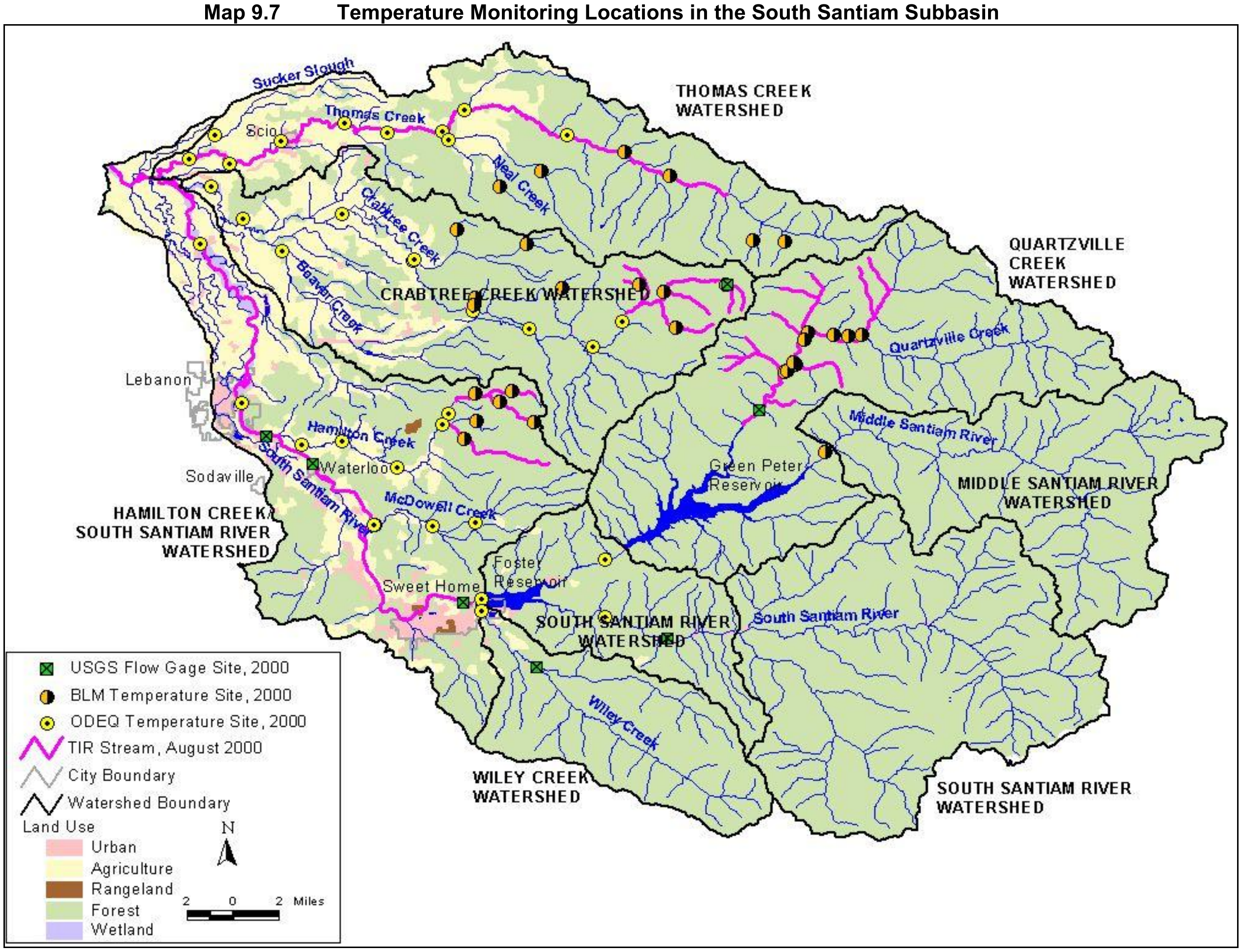
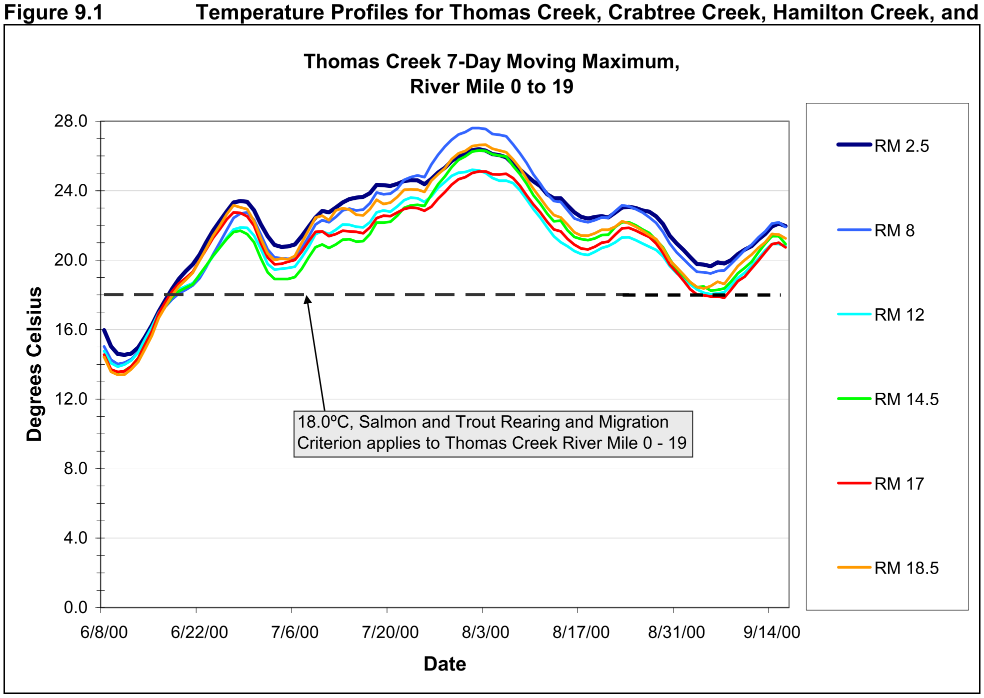


Figure 9.1 Temperature Profiles for Thomas Creek, Crabtree Creek, Hamilton Creek, and McDowell Creek.



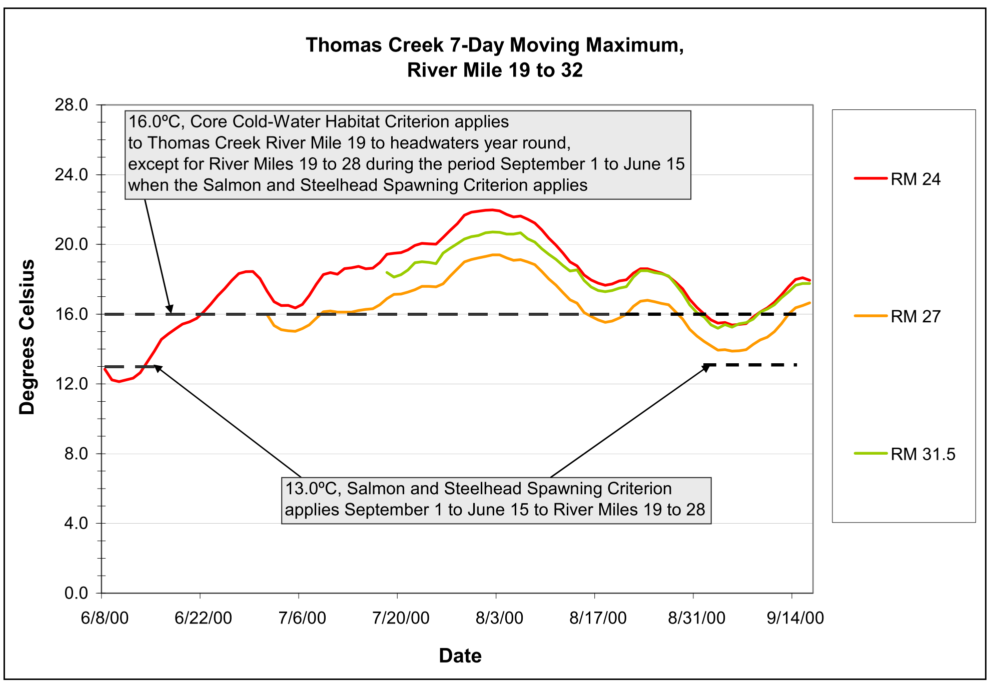
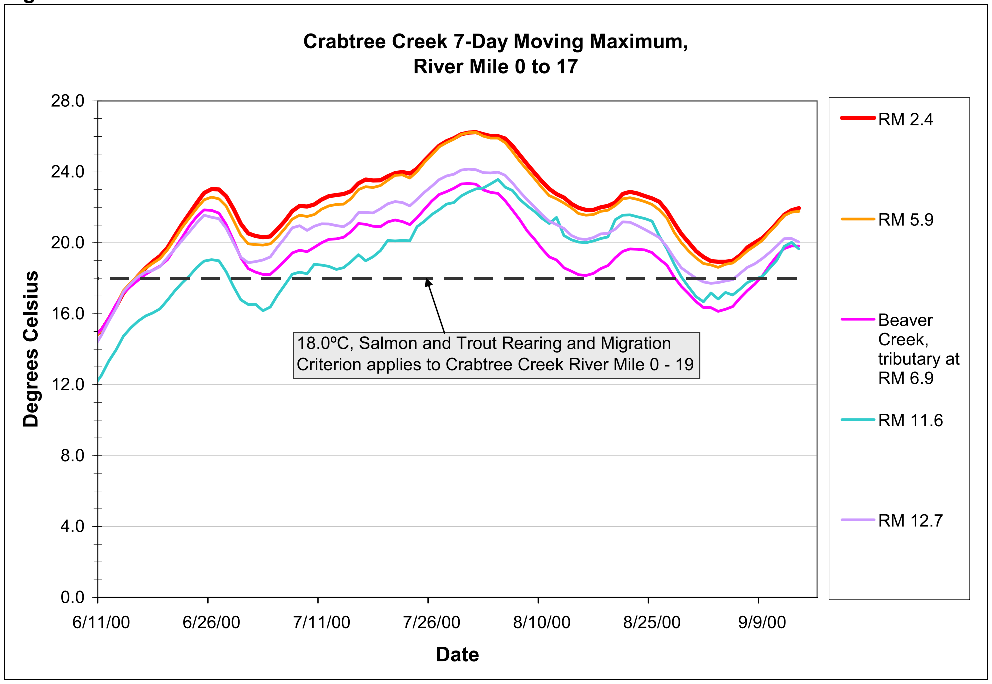
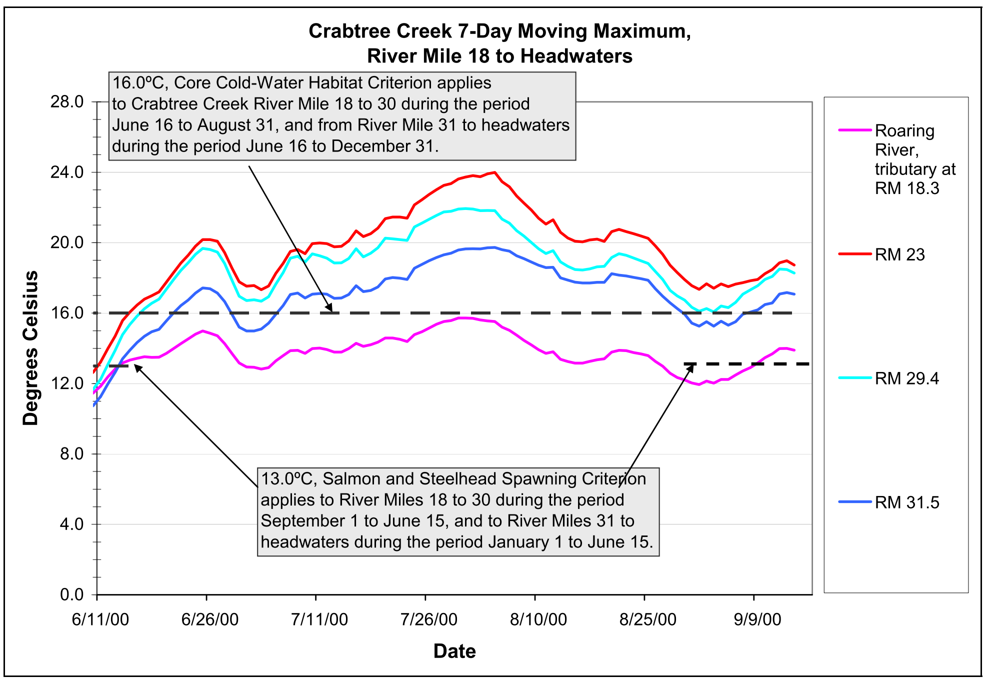
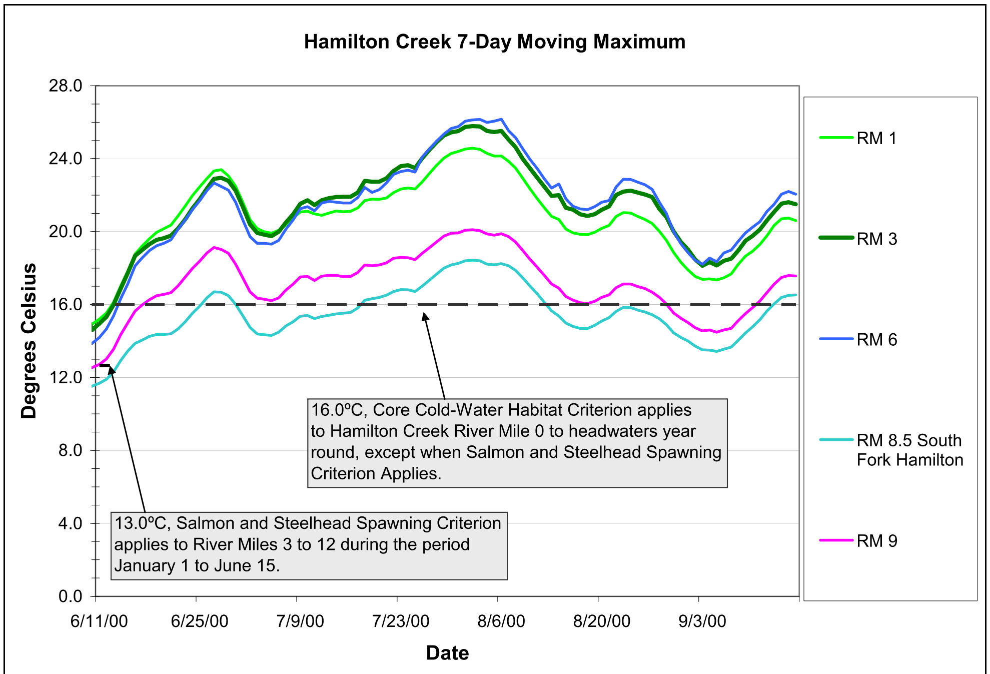


Figure 9.1 continued






Hamilton Creek 7-Day Moving Maximum
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
Degrees Celsius
6/11/00
6/25/00
7/9/00
7/23/00
8/6/00
8/20/00
9/3/00
Date
16.0ºC, Core Cold-Water Habitat Criterion applies to Hamilton Creek River Mile 0 to headwaters year round, except when Salmon and Steelhead Spawning Criterion Applies.
13.0ºC, Salmon and Steelhead Spawning Criterion applies to River Miles 3 to 12 during the period January 1 to June 15.
RM 1
RM 3
RM 6
RM 8.5 South Fork Hamilton
RM 9

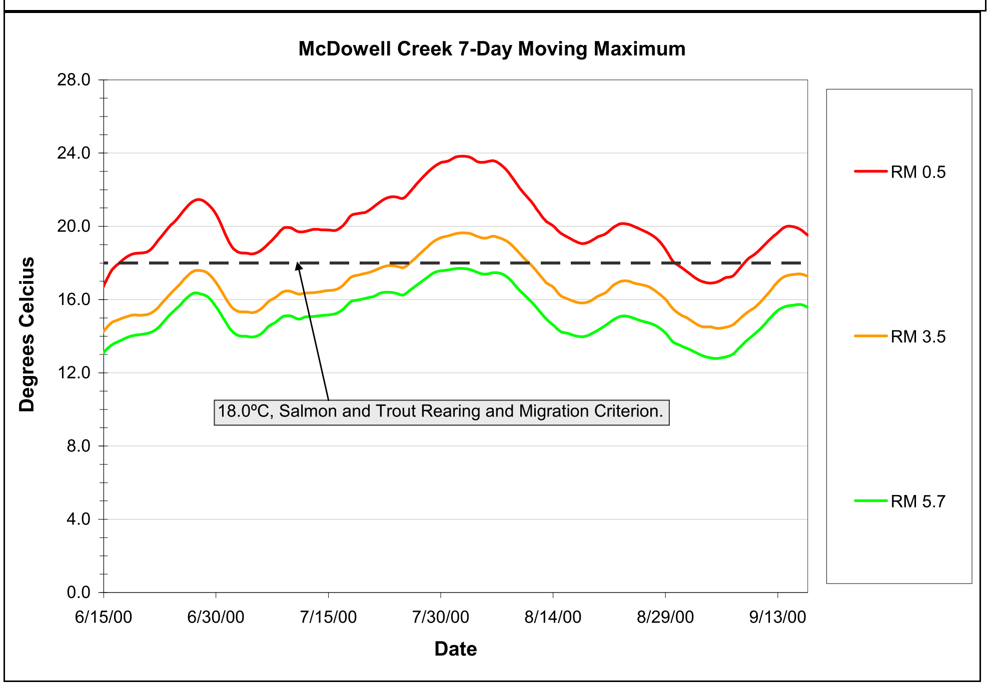

McDowell Creek 7-Day Moving Maximum
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
Degrees Celcius
6/15/00
6/30/00
7/15/00
7/30/00
8/14/00
8/29/00
9/13/00
Date
18.0ºC, Salmon and Trout Rearing and Migration Criterion.
RM 0.5
RM 3.5
RM 5.7

Figure 9.2 TIR/Day TV image mosaic (frames: thom0785-thom0787) showing the confluence of Thomas Creek 23.6ºC (74.48ºF) and Neal Creek 19.6ºC (67.28ºF). Thomas Creek flows from the top to bottom of the image. August 3, 2000.

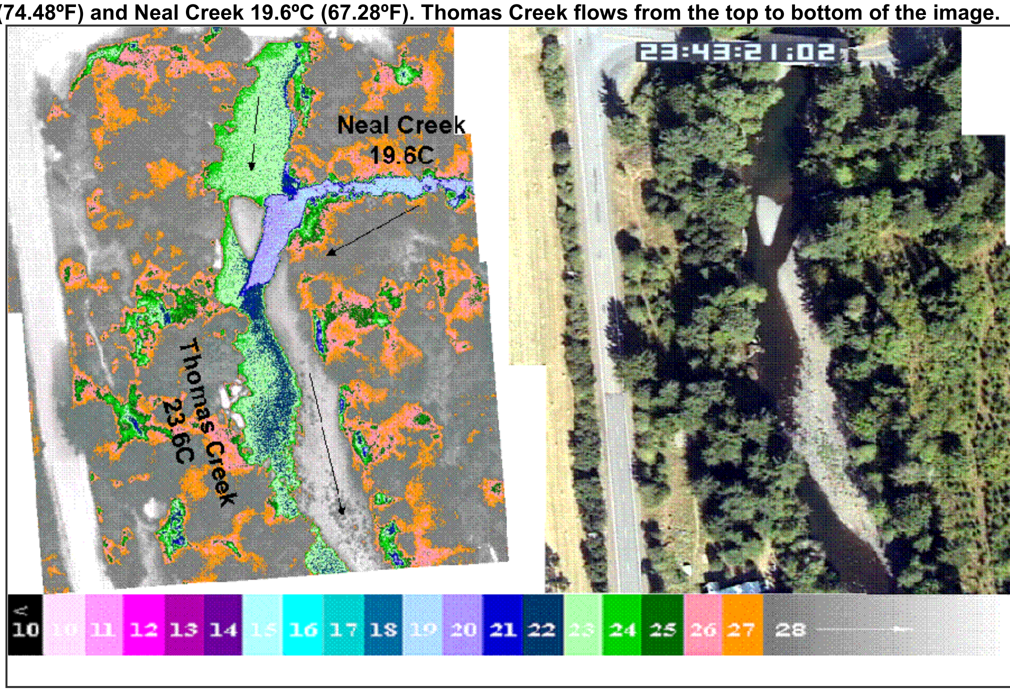


Figure 9.3 TIR/Day TV image mosaic (frames: thom0299-thom0304) showing Thomas Creek 24.9ºC (76.82ºF) at river mile 6.0. The image shows cooler water along the left bank (looking downstream). The cooler area is probably due to subsurface flow through the flood plain. August 3, 2000. The riparian vegetation is not at system potential along the right bank adjacent to the open field.

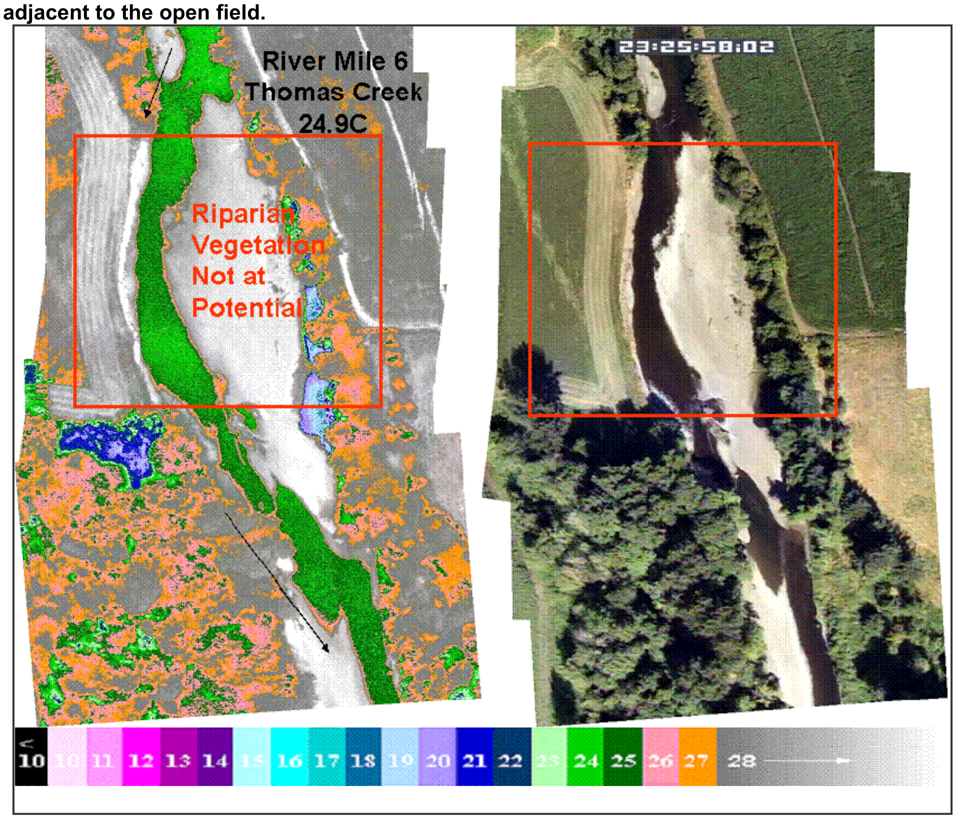


Figure 9.4 TIR/Day TV image pair (ss0112) showing the confluence of Thomas Creek, 24.1ºC (75.38ºF), and the South Santiam River, 20.3ºC (68.54ºF). The South Santiam River flows from the top to bottom of the image. Thomas Creek flows in from the top left of the image. A cold seep is detected just downstream of the confluence. August 3, 2000.

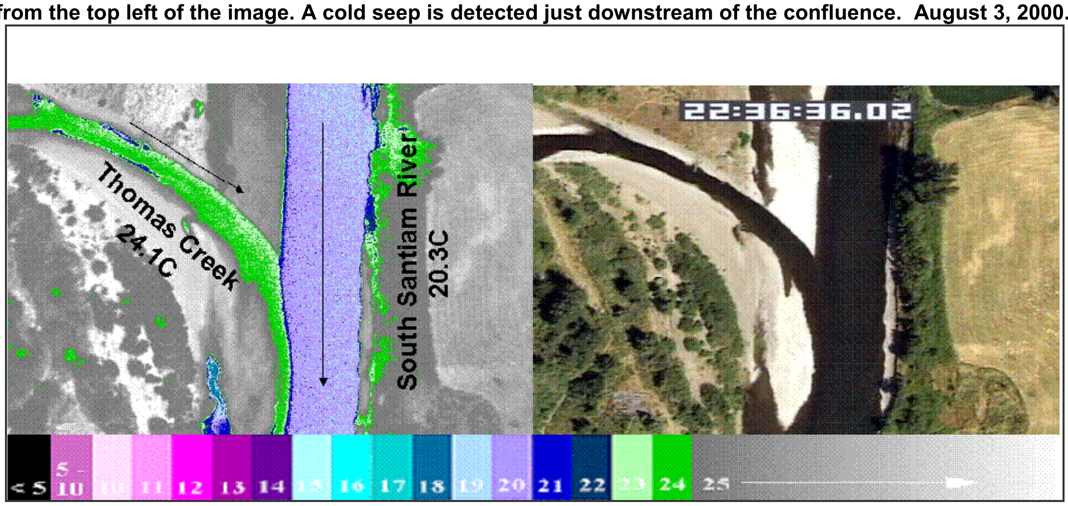
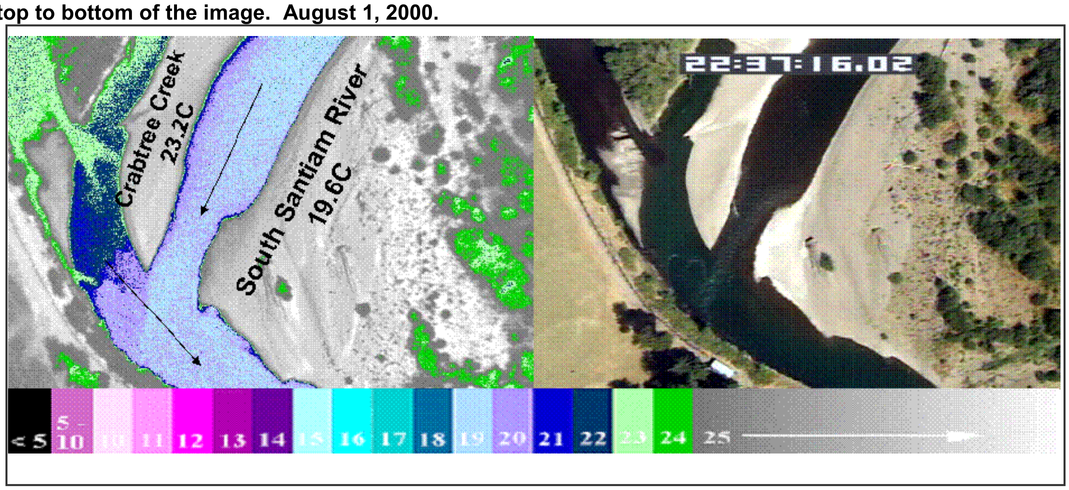


Figure 9.5 TIR/Day TV image pair (ss0132) showing the confluence of Crabtree Creek, 23.2ºC (73.76ºF), and the South Santiam River, 19.6ºC (67.28ºF). Crabtree Creek enters from the left side of the image while the South Santiam River flows from top to bottom of the image. August 1, 2000.



Loading Capacity
OAR 340-042-0040(4)(d), 40 CFR 130.2 (f)

The loading capacity is the total amount of a pollutant that a water body can assimilate without exceeding a water quality criterion or impairing a beneficial use. This is the pollutant load that may be divided among all point and nonpoint sources as allocations.

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with water quality standards. USEPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*" (40 CFR § 130.2(f)). Oregon's temperature criteria states that a surface water temperature increase of no more than 0.3°C (0.54ºF) above the applicable criterion is allowed from all anthropogenic sources at the point of maximum impact.

The loading capacity is dependent on the available assimilative capacity of the receiving water. For water bodies whose natural thermal potential temperatures are at or above the temperature criterion for a given period, there is no available assimilative capacity beyond the 0.3°C (0.54ºF) human use allocation. The loading capacity is essentially consumed by non-anthropogenic sources. When natural thermal potential temperatures are less than biological based numeric criteria, the load capacity may be somewhat greater than the human use allowance provided additional heat loads do not prevent attainment of water quality standards in downstream waters.

Critical Condition

The critical condition for stream temperature and heat loading is the seasonal period of maximum stream temperatures and lowest stream flows. Maximum stream temperatures are often a function of the combined effects of atmospheric inputs (solar radiation) and low stream flows that usually occur during the summer period. For many point sources the most critical condition for complying with the human use allowance occurs during the period of low stream flow and when there is large difference between effluent and river temperatures, usually in late summer to early fall.

Allocations

40 CFR 130.2(g), 40 CFR 130.2(h)

Loading capacity is allocated among point sources as wasteload allocations and to nonpoint sources as load allocations. Load allocations to anthropogenic sources are only available where surface water temperatures throughout a given stream meet the applicable water quality criteria plus the human use allowance. The general principle for allocation in the South Santiam Subbasin is to target natural background heat inputs from nonpoint sources and to limit point source loads to small allocations within the human use allowance.

Wasteload Allocations

OAR 340-042-0040(4)(g)

A wasteload allocation (WLA) is the amount of pollutant that a point source can contribute to the stream without violating water quality criteria. Waste load allocations for temperature are expressed as heat load limits assigned to individual point sources of treated industrial and domestic waste. Waste load allocations are provided for all NPDES facilities that have reasonable potential to warm the receiving stream when the applicable criteria are exceeded. Major and minor sources included in this TMDL do not discharge during the critical period in summer and no WLAs have been provided for these point sources. If necessary, wasteload allocations and permit limits will be developed by the methods following in this section. Facilities found not to be a significant contributor of heat to subbasin streams and found not to have a reasonable potential to contribute to the temperature impairment in the subbasin and therefore require no numeric limits in their NPDES permit may continue to discharge at their current heat load. Again, point sources that discharge directly to the South Santiam River downstream of Foster Reservoir have been considered as part of the mainstem Willamette TMDL detailed in Chapter 4.

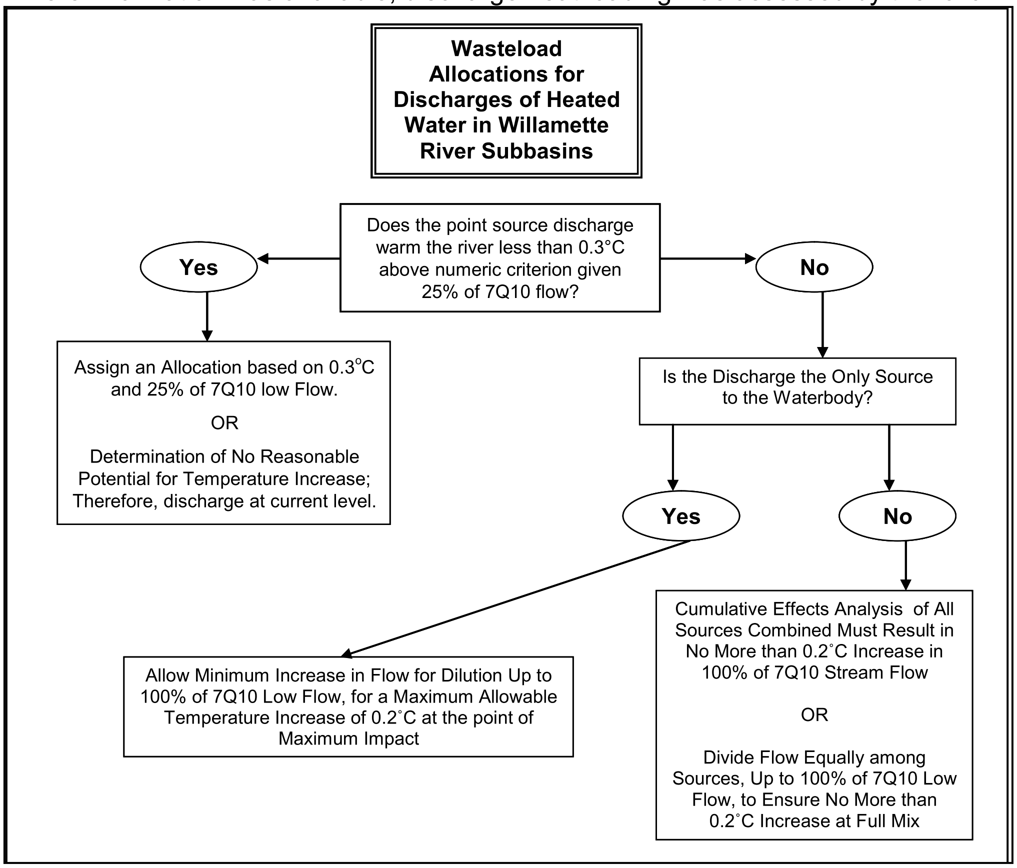
Waste Load Allocations in Small Streams

Discharges were screened to determine which would likely receive a wasteload allocation based on the type of discharge, and the volume and temperature of effluent. General permits that are unlikely to discharge significant volumes of warm water during critical periods (e.g., stormwater permits) are not expected to have a reasonable potential to increase in-stream temperatures. General permits that discharge heated effluent (e.g., boiler blowdown, log ponds) were considered as potential sources. For discharges with insufficient information (absence of stream flow data) to screen for effects or develop a wasteload allocation (WLA), a WLA will be calculated at the time of permit renewal by the method described below.

Oregon's temperature standard [OAR 340-041-0028(12)] allows an insignificant increase in temperature from all point source and nonpoint sources combined as a human use allowance (HUA = 0.3˚C). Prior to development of a TMDL, the standard allows the assumption that a 0.3˚C increase in ¼ of the receiving stream flow or the volume of the temperature mixing zone (whichever is more restrictive) will not cause an impairment.

The waste load allocation scheme below assumes an allowable change in temperature above criteria of 0.3˚C within 25% of the 7Q10 low flow (a calculation of the seven-day, consecutive low flow with a ten year return frequency). This is the initial step in the development of a waste load allocation on smaller streams or when information is insufficient to allow a greater proportion of receiving water flow for mixing. The resultant temperature increase in fully mixed receiving water would be limited to 0.08˚C. More than the minimum flow allowance (25% of 7Q10 low flow) may be allocated to an individual source when analysis demonstrates standards attainment. The resulting temperature increase in this scenario depends on the proportion of low flow allocated, but should not exceed the point source sector allocation of 0.2°C over the entire waterbody. Moreover, each discharge is also required to ensure the local effects of discharge will not cause impairment to health of fish by meeting thermal plume requirements adopted under OAR 340-41-0053(2)(d).

Where information was available, discharge heat loading was assessed by the following process:



The pre-TMDL limits in the flow chart above refer to currently permitted discharge limits for existing point sources. Wasteload allocations are expressed in terms of heat load (kilocalories per day). These heat loads are calculated from estimates of river flow, effluent flow, effluent temperature, and either the appropriate biologically based criterion or the natural thermal potential at the point of discharge. Heat load is calculated with **Equation 1** (below). Where in-stream and effluent flow information is sufficient, allocations, and effluent limits may be developed based on flow rates for time periods other than monthly or an entire season (e.g., daily loads). The Q_{ZOD} term may vary depending upon the situation for the discharger as explained in the decision tree above, but will usually be ¼ of the 7Q10 low flow on either a monthly or a yearly basis dependent on data availability.

Equation 1:

where:

$$H_{PS} = (Q_{ZOD} + Q_{PS}) \frac{1 \cdot ft^3}{1 \cdot sec} \cdot \frac{1 \cdot m^3}{35.31 \cdot ft^3} \cdot \frac{1000 \cdot kg}{1 \cdot m^3} \cdot \frac{86400 \cdot sec}{1 \cdot day} \cdot \Delta T_{ZOD} \cdot c = \frac{Kcal}{day}$$

H_{PS}: Heat from point source effluent received by river (kcal/day)
Q_{ZOD}: River flow volume allowed for mixing- ¼ of 7Q10 low flow statistic (cfs)
Q_{PS}: Point source effluent discharge (cfs)
ΔT_{ZOD}: Change in river temperature at point of discharge - 0.3°C allowable (°C)
c: Specific heat of water (1 Kcal / 1kg 1ºC)

Estimates of effluent temperature were calculated using mass loading equations (**Equation 2**) taking into account river flow and temperature, and effluent flow and temperature. Allocations are usually calculated to ensure an increase in temperature of no more than 0.3°C (0.54°F) in one-quarter of the volume of the receiving stream. When this volume is fully mixed with the receiving stream, this increase in temperature would be limited to 0.08°C. Where more than the minimal flow volume is allocated, either to allow more heat load to an individual discharger on a stream, or to calculate the cumulative effects of multiple discharges, the allocation is no more than 0.2°C (0.36°F) increase given the entire flow of the river receiving the cumulative discharges. If new or more comprehensive information (e.g. flow data, temperature data, mixing zone characteristics) is available at the time permits are renewed, permit limits will reflect revised wasteload allocations as calculated using **Equation 1** above and the best information available.

Equation 2:

$$T_{WLA} = \frac{[(Q_{PS} + Q_{ZOD}) \cdot (T_R + \Delta T_{ZOD})] - (Q_{ZOD} \cdot T_R)}{Q_{PS}}$$

where:
T_R: Temperature Criterion or Upstream potential river temperature (°C)
T_{WLA}: Maximum allowable point source effluent temperature (° C)
ΔT_{ZOD}: Change in river temperature at point of discharge - 0.3°C allowable (°C)
Q_{ZOD}: River flow volume allowed for mixing- ¼ of 7Q10 low flow statistic (cfs)
Q_{PS}: Point source effluent discharge flow volume (cfs)

No waste load allocations were developed in this TMDL as they are unnecessary to demonstrate attainment of water quality standards in impaired streams because they were found to not discharge during the critical period. However, waste load allocations will be developed for all permitted sources that discharge heated waste water to subbasin waters using Equations 1 and 2 (above). Waste load allocations for existing and future thermal point sources will ensure that the sum of waste load and load allocations result in an increase in stream temperature of no greater than 0.3°C above the applicable criteria after complete mixing and at the point of maximum impact. Pollutant trading opportunities may be available to new or existing point sources in order to offset temperature impacts.

Load Allocations

OAR 340-042-0040(4)(h)

Load Allocations are portions of the loading capacity divided among natural, current anthropogenic, and future anthropogenic nonpoint pollutant sources. Load allocations (i.e. distributions of the loading capacity) are provided in Table 9.7 for Crabtree and Thomas creeks.

In this TMDL, load allocations are allowed 0.05˚C of the human use allowance (0.3˚C). This heat allowance is in addition to the load that streams would receive when they are at system potential and would allow activities that might increase the loading (such as riparian management activities) or for human disturbance that may not easily be addressed (e.g. presence of a road near a stream that would limit shading). The 0.05°C increase in temperature above criteria (1/6th of the HUA) is dedicated to nonpoint sources but is not allocated to individual sources at this time.

The current loading from nonpoint sources is much greater than that which would exist under natural thermal potential. This requires nonpoint sources to reduce thermal inputs to reach natural thermal potential conditions through allocation of a surrogate measure, effective shade. The principal means of achieving this condition is through protection and restoration of riparian vegetation. Additional measures may also be taken to improve summer temperatures. For example, water conservation measures that improve summer stream flows will benefit stream temperatures through an increase in load capacity. Stream restoration efforts that result in narrower stream channel widths will improve the effectiveness of existing vegetation to shade the stream surface.

Nonpoint source allocations were assigned natural background loads and are implemented as shade curves for upland forests and each geomorphic unit. This allocation also applies to tributaries of temperature listed waterbodies. Shade curves illustrate the relationship between each potential vegetation cover type, channel width and the resulting effective shade level.

The total nonpoint source solar radiation heat load was derived for Thomas Creek and Crabtree Creek. Current solar radiation loading was calculated by simulating current stream and vegetation conditions using the Heat Source Temperature Model version 6.5. Background loading was calculated by simulating the solar radiation heat loading that resulted with system potential vegetation. This background condition, based on system potential vegetation, reflects an estimate of nonpoint source heat load that would occur while meeting the temperature criterion. The relationships below were used to determine solar radiation heat loads for the current condition, anthropogenic contributions, and loading capacity derivations based on system potential:

Solar Radiation Heat Load Calculation Diagram

Total Solar Radiation Heat Load from All Nonpoint Sources,

$$H_{Total\ NPS} = H_{SP\ NPS} + H_{Anthro\ NPS} = \Phi_{Total\ Solar} \cdot A$$

Solar Radiation Heat Load from Background Nonpoint Sources (*System Potential*),

$$H_{SP\ NPS} = \Phi_{SP\ Solar} \cdot A$$

Solar Radiation Heat Load from Anthropogenic Nonpoint Sources,

$$H_{Anthro\ NPS} = H_{Total\ NPS} - H_{SP\ NPS}$$

Note: All solar radiation loads are the clear sky received loads that account for Julian time, elevation, atmospheric attenuation and scattering, stream aspect, topographic shading, near-stream vegetation stream surface reflection, water column absorption and stream bed absorption.

where,

$H_{Total\ NPS}$: Total Nonpoint Source Heat Load (kcal/day)
$H_{SP\ NPS}$: Background Nonpoint Source Heat Load based on *System Potential* (kcal/day)
$H_{Anthro\ NPS}$: Anthropogenic Nonpoint Source Heat Load (kcal/day)
$\Phi_{Total\ Solar}$: Total Daily Solar Radiation Load (ly/day)
$\Phi_{SP\ Solar}$: Background Daily Solar Radiation Load based on *System Potential* (ly/day)
$\Phi_{Anthro\ Solar}$: Anthropogenic Daily Solar Radiation Load (ly/day)
A: Stream Surface Area - calculated at each 100 foot stream segment node (cm^2)

System Potential vegetation characteristics were developed to include the effects of natural disturbance on riparian vegetation distribution and attributes within each geomorphic unit. The term "geomorphic unit" refers to quaternary geologic units shown as polygons that were differentiated on the basis of stratigraphic, topographic, pedogenic, and hydrogeologic properties (O'Connor et al, 2001). In other words, surface deposits of unconsolidated material above bed rock shaped by processes of erosion, sediment transport and deposition.

Natural disturbance includes among other processes:

- Flood
- Wind Throw
- Fire
- Insect Infestation

System potential vegetation includes the random distribution of conifer, mix conifer-hardwood, and hardwood species in each geomorphic unit. This random distribution of attributes within each geomorphic unit is intended to include the effects of natural disturbance in the system potential riparian vegetation condition. Some geomorphic units may also incorporate prairie. The proportions of forest, savanna and prairie to be used in each geomorphic unit were developed following rules detailed in Table 1 and on page 14 of the Potential Near-Stream Land Cover document included in Appendix C. As an example, in the quaternary alluvium unit (Qalc) which is unconsolidated silt, sand, and gravel of the Willamette River and major Cascade Range tributaries the vegetation distribution includes 80% forest, 17% savanna and 3% prairie. Forest land includes a mix of conifer (4%), hardwood (3%) and mixed (93%) forests, which determine the shade characteristics of the near-stream plant community.

A total of 66 river miles in Thomas Creek and Crabtree Creek, were analyzed and simulated during the critical period, August 3rd and 2nd, 2000 respectively. The stream temperatures that result from system potential riparian conditions for Thomas Creek, Figure 9.6, and Crabtree Creek, Figure 9.7 are presented. These graphs represent the maximum daily stream temperatures observed longitudinally downstream. A decrease in the maximum observed daily maximum stream temperatures are observed for both creeks when system potential riparian vegetation is applied. The stream temperatures that result from system potential riparian vegetation are the allocated condition.

Figure 9.6 Thomas Creek distribution of maximum daily stream temperatures at current conditions and system potential vegetation.

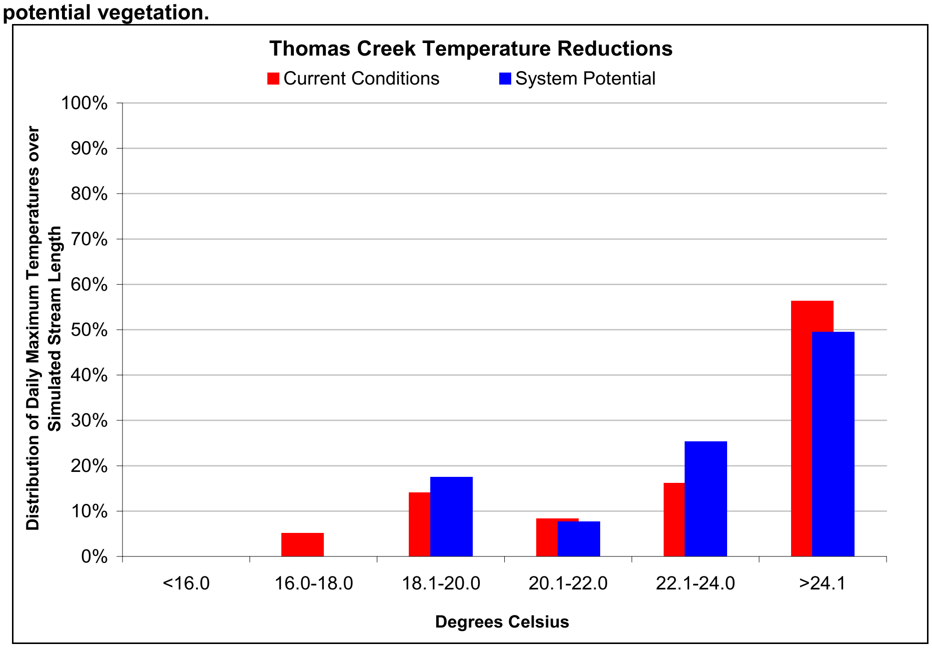
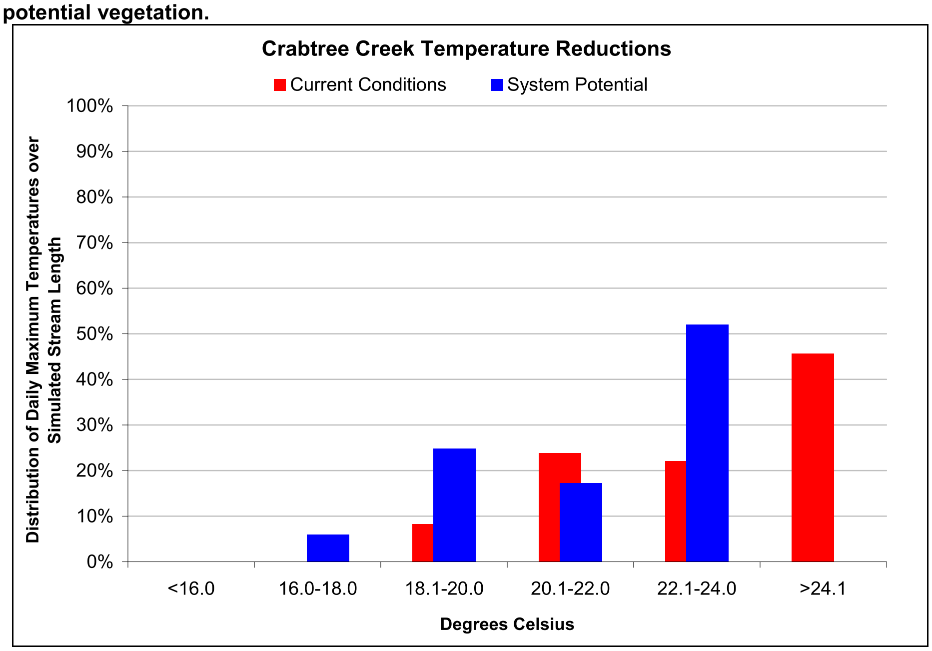


Figure 9.7 **Crabtree Creek distribution of maximum daily stream temperatures at current condition and system potential vegetation.**



The percent effective shade calculated for current conditions versus system potential vegetation conditions for Thomas Creek and Crabtree Creek averaged over a 1 km (0.6 miles) distance is shown in Figure 9.8 and 9.9. Typically system potential vegetation provides greater percent effective shade values to the stream, however in specific reaches of each creek the simulated system potential vegetation conditions yields lower effective shade values than current conditions. This decrease in effective shade under system potential conditions is due in part to the random distribution of natural disturbance included in the system potential vegetation. For example, the system potential condition at RM 15 in Crabtree Creek may have accounted for a disturbance in the riparian community when in fact under current conditions the riparian community at RM 15 is not a disturbed riparian community.

Figure 9.8 **Thomas Creek Longitudinal Percent Effective Shade Profile of Current Conditions versus System Potential Vegetation, averaged over a 1 km distance.**

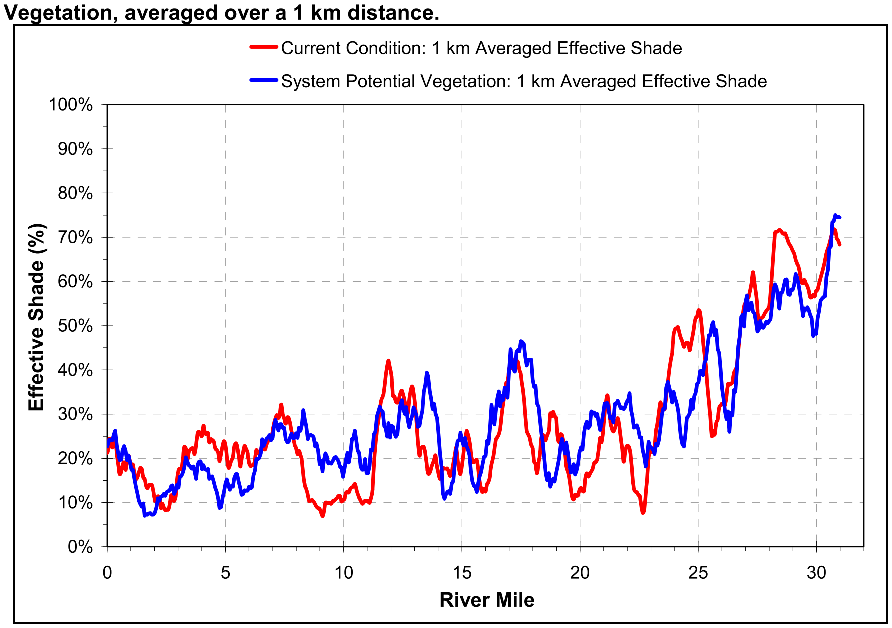
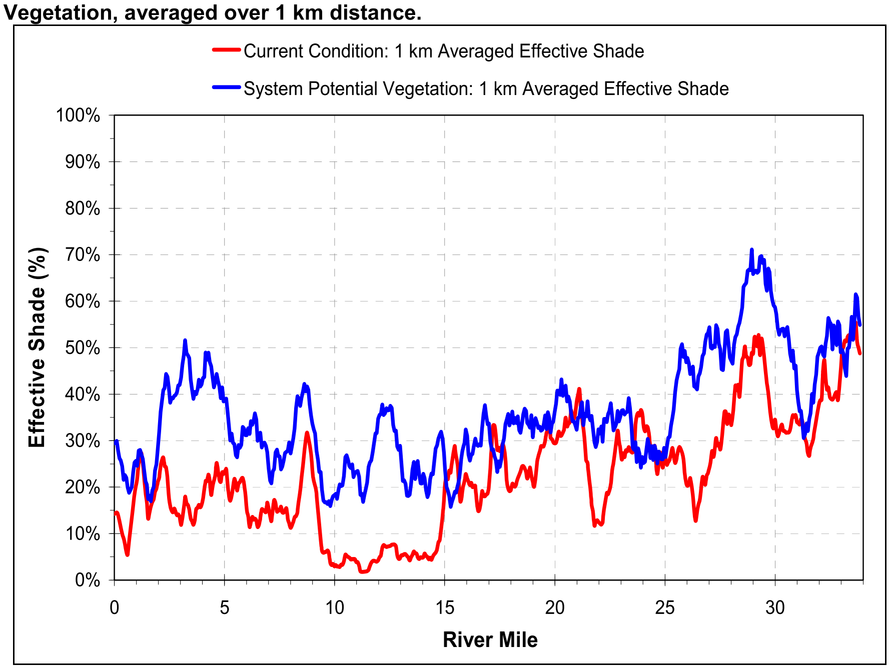


Figure 9.9 Crabtree Creek Longitudinal Percent Effective Shade Profile of Current Conditions versus System Potential Vegetation, averaged over 1 km distance.



It is expected that effective shade values would increase if stream channel widths decreased and riparian vegetation increased. Decreasing channel widths would increase the effectiveness of the system potential vegetation to shade the stream and in effect decrease in-stream temperatures, and also decrease the width-to-depth ratio of the stream. On a stream system average there is about a 5% increase in effective shade in Thomas Creek and a 15% increase in effective shade in Crabtree Creek under system potential vegetation conditions.

A summary of the solar radiation loads for Thomas and Crabtree creeks at current and system potential conditions is shown in Table 9.7 The difference between current and system potential conditions is the calculated anthropogenic load for nonpoint sources. This table does not represent all listed waterbodies in the subbasin but only those where resources and priority allow for load calculation. The Thomas Creek model was calibrated for August 3rd, 2000, utilizing TIR data and in-stream thermister data. Modeling of Thomas Creek with system potential riparian vegetation indicates that 10.11×10^8 kcal/day heat load is attributed to system potential condition and 0.03×10^8 kcal/day is due to anthropogenic sources. The Crabtree Creek model was calibrated for August 2nd , 2000, to in-stream thermisters data. Modeling of the creek with system potential riparian vegetation indicates that 13.2×10^8 kcal/day heat load is attributed to system potential condition and 2.64×10^8 kcal/day is due to anthropogenic sources.

Table 9.7 Thomas Creek and Crabtree Creek Solar Radiation Load Summary.

Stream	Current Condition (10^8 kcal/d) $H_{Total\ NPS}$	System Potential Condition (background) (10^8 kcal/d) $H_{SP\ NPS}$	Anthropogenic $H_{Anthro\ NPS}$ (10^8 kcal/d)
Thomas Creek	10.14	10.11	0.03
Crabtree Creek	15.84	13.20	2.64
Totals	**25.98**	**23.31**	**2.67**

The point of maximum impact for anthropogenic sources of heat is defined as the point in the stream where the maximum change in temperature between natural thermal potential temperature and current temperatures are observed. In Thomas Creek and Crabtree Creek this is where the differences between system potential vegetation and current vegetation conditions most affect stream temperatures. The point of maximum impact occurs at river mile 20.0, downstream of Bear Creek, in Thomas Creek. The change between current condition stream temperatures and system potential vegetation temperatures at the point of maximum impact is 1.14°C (2.1°F). At the mouth of Thomas Creek the maximum current condition temperature is 25.0°C (77.0°F), and simulations suggest this temperature would not decrease under system potential vegetation. The point of maximum impact for Crabtree Creek occurs at RM 3.3, downstream of Hoffman Bridge. The change between current condition and system potential vegetation stream temperatures at RM 3.3 is 3.8°C (6.8°F). At the mouth Crabtree Creek current condition temperature is 25.8°C (78.4°F), simulations suggest this temperature would decrease under system potential vegetation to 23.9°C (75.0°F).

In addition to system potential vegetation other restoration efforts may decrease stream temperatures. These include:

- Restoring stream channel morphology
- Increasing stream channel complexity
- Restoring floodplain processes
- Restoring natural stream flow
- Decreasing tributary stream temperatures

A sensitivity analysis was performed on the calibrated Thomas Creek Heat Source model in response to system potential vegetation, decreased tributary stream temperatures (tributary temperatures at numeric criteria), and increased instream flow (stream flow without points of diversion withdrawals). This sensitivity analysis showed a decrease in system potential stream temperatures and an increase in effective shade values in Thomas Creek when compared to the system potential vegetation model run that the solar radiation loads are based on in Table 9.7. Simulation output demonstrates that cooler maximum temperatures are likely with improvements in stream flow and cooler tributary inflow, see the Subbasin Temperature Analysis document in Appendix C.

Excess Load

OAR 340-042-0040(4)(e)

The excess load is the difference between the actual pollutant load and the loading capacity of a water body. Load allocations for nonpoint sources are based on system potential vegetation. Riparian information collected by the ODEQ, USFS, and BLM, and analyzed by ODEQ indicates that there is inadequate shade throughout the South Santiam Subbasin. ODEQ data also suggest shade levels are less than system potential at Thomas Creek, Crabtree Creek, Hamilton Creek, and McDowell Creek. Excess heat loading occurs wherever inadequate shade levels are widespread.

Surrogate Measures

OAR 340-042-0040(5)(b,) 40 CFR 130.2(i)

The South Santiam Subbasin Temperature TMDL incorporates measures other than “daily loads” in allocating heat to nonpoint sources. These measures are termed surrogate measures. The applied surrogate measure in this temperature TMDL is percent effective shade expressed as a shade curve. Shade curves have been developed for each geomorphic unit in the Willamette Valley and upland forest area of the Cascade and Coast Ranges in the Willamette Basin. Shade curves determine the nonpoint source load allocation. They were developed using trigonometric equations estimating the shade underneath tree canopies.

Percent effective shade is perhaps the most straightforward stream parameter to monitor and calculate. It is easily translated into quantifiable water quality management and recovery objectives. Percent effective shade is defined as the percentage of direct beam solar radiation attenuated and scattered before reaching the ground or stream surface, commonly measured with a Solar Pathfinder.

Shade curves represent general relationships between the percent effective shade reaching the stream surface, solar radiation loading of the stream, system potential vegetation, stream aspect from north, and the width of the channel. The channel width, Figure 9.10, is the distance from the edge of right bank vegetation to the edge of left bank vegetation.

Figure 9.10 The Channel width and wetted width.

System potential vegetation has been developed for each geomorphic unit in the Willamette Basin. System potential vegetation is defined as the riparian vegetation which can grow and reproduce on a site given the plant biology, site elevation, soil characteristics, and local climate. However, it does not include considerations for resource management, human use, and other human disturbances. A natural disturbance regime has been incorporated into the riparian composition for each geomorphic region that includes provisions for fire, disease, wind-throw, and other natural occurrences. Each shade curve translates the amount of percent effective shade that each geomorphic unit tree composition provides to the stream based on the streams channel width and stream aspect from north. Each geomorphic unit is composed of a percentage of forest, savannah, and prairie and reflects the tree species composition that will grow and reproduce in each geomorphic unit. For a detailed description of the system potential vegetation development and of the riparian tree species composition for each geomorphic unit please see "Potential Near-Stream Land Cover for Willamette Basin TMDL Determination", Appendix C. A shade curve has been developed for each geomorphic and upland forest unit in the South Santiam Subbasin, Map 9.8 to 9.12 and Figure 9.11. Watershed geomorphic maps that represent more than one geomorphic unit are shown for Thomas Creek, Crabtree Creek, Hamilton Creek / South Santiam River, Wiley Creek, and the South Santiam River watersheds; the following watersheds are to apply the upland forest geomorphic unit to all streams: Quartzville Creek, Middle Santiam River, and South Santiam River watersheds.

The relative areas of the geomorphic classifications of the South Santiam Subbasin are presented in Table 9.8. Despite the relatively fine scale of the geomorphic classifications, the differences among the various shade curves are subtle in some cases.

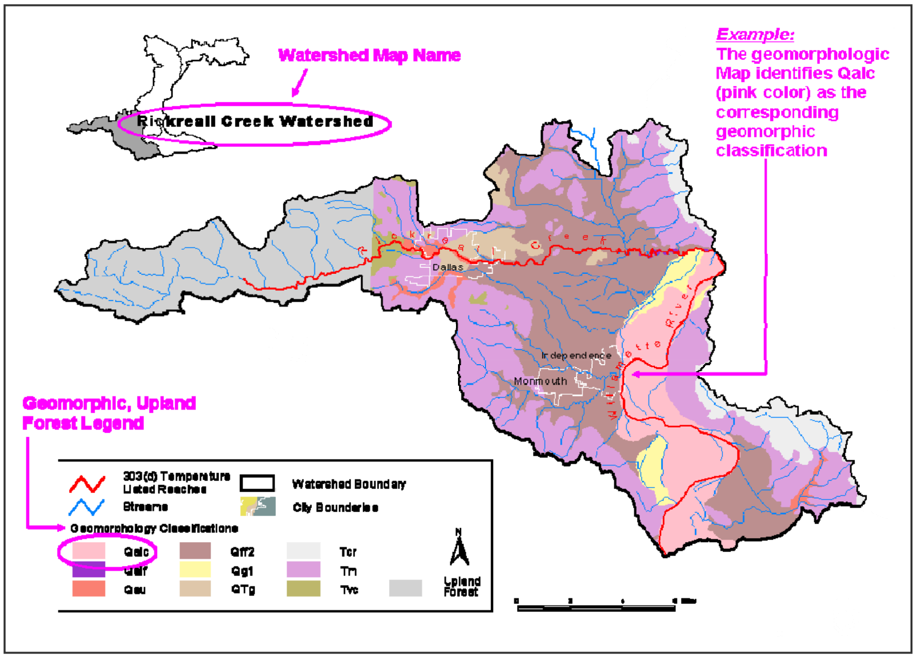
Table 9.8 Area of Geomorphic Units in South Santiam Subbasin. Values are Ranked in Order of Increasing Area.

Geomorphic Class	Acres	Square Miles	Relative Area (%)
Tertiary Marine sedimentary rock (Tm)	196	0.3	0.03
Open Water	931	1.5	0.14
Fine-grained quaternary alluvium (Qalf)	1,969	3.1	0.30
Quaternary Landslide deposits (Qls)	2,151	3.4	0.32
Pre-Flood Quaternary sand/gravel (Qg2)	4,625	7.2	0.69
Quaternary fine-grained Flood deposits (Qff2)	5,061	7.9	0.76
Post Flood Quaternary sand/gravel (Qg1)	7,819	12.2	1.17
Tertiary Columbia River Basalt (Tcr)	13,212	20.6	1.98
Undifferentiated Quaternary Alluvium (Qau)	13,213	20.6	1.98
Quaternary fine-grained alluvium (Qbf)	19,875	31.1	2.98
Quaternary terrace gravels (QTg)	21,451	33.5	3.22
Quaternary alluvium floodplain deposits (Qalc)	22,917	35.8	3.44
Western Cascades tertiary volcanics (Tvw)	145,377	227.2	21.82
Upland Forests (Uf)	407,392	636.6	61.15
Total	**666,190**	**1,040.9**	**100**

How to Use a Shade Curve:

1. Determine the applicable geomorphic or upland forest unit that applies to the stream reach you are applying a Shade Curve to.

Example: You are located in the Rickreall Creek watershed, in the city of Independence along the west bank of the Willamette River. By using the appropriate map, below, you identify the geomorphic unit on your property to be Qalc (Quaternary alluvium floodplain deposits).



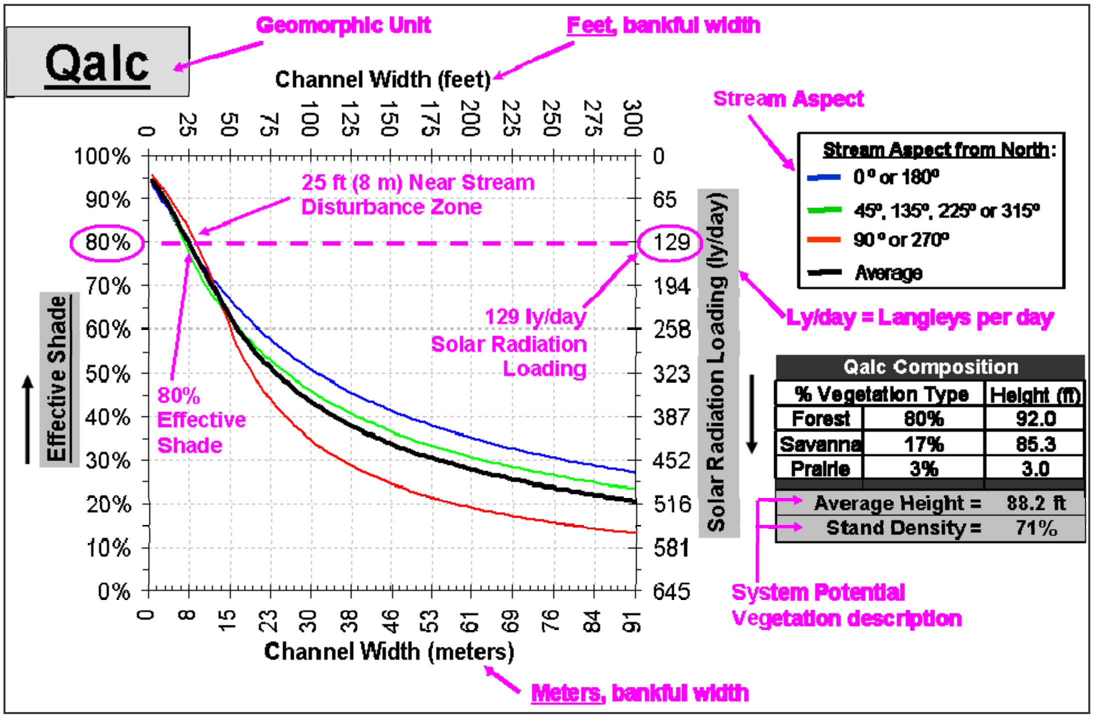
2. Determine the stream aspect from north.

Example: Based on your location on a tributary to the west bank of the Willamette River in Independence, standing in-stream mid-channel, facing north you determine the river's aspect as 0º or 180º from north (this means the river reach runs south to north).

3. Determine the channel width of the stream reach.

Example: At your location you measure the channel width using a tape measure or lasar range finder, you determine the stream width is 25 feet.

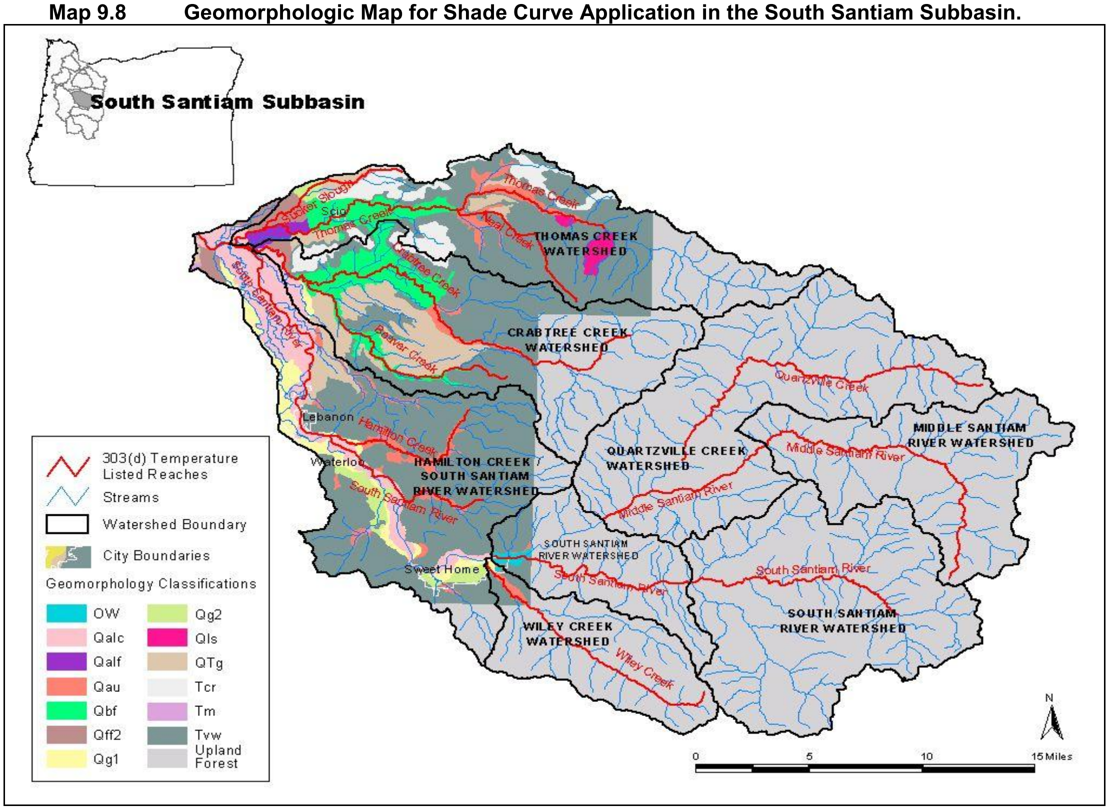
4. Using the appropriate geomorphic or upland forest Shade Curve, using the appropriate stream aspect line and channel width (x-axis), read the y-axis to determine the percent effective shade and solar radiation loading. This is the non-point source load allocation of the stream reach at system potential vegetation.



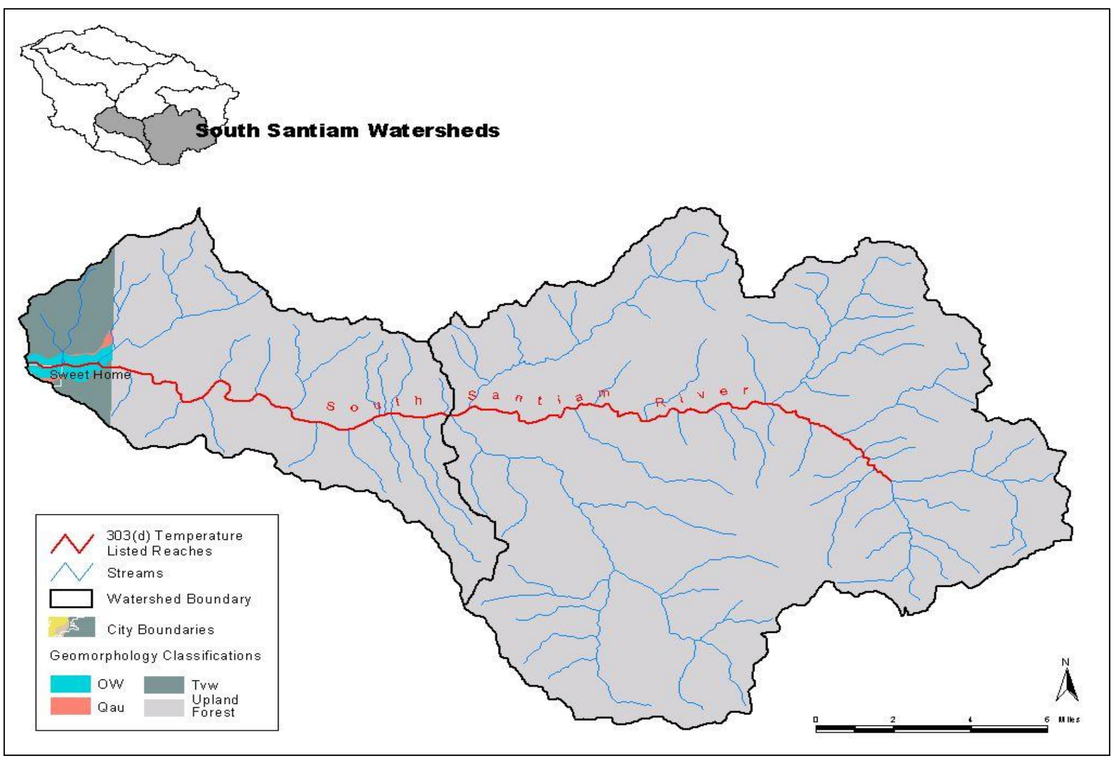
Example: A tributary to the Willamette River on the west bank near Independence with a stream aspect from north of 0º or 180º (blue line) and a channel width of 25 feet: using the blue line to determine the loading capacity from the x-axis identify the 25 feet (8 m) mark and read the y-axis, the solar radiation loading would be 129 Langleys/day with 80% effective shade when system potential vegetation is applied to the left and right bank of the stream reach. System potential vegetation identifies the riparian average height, 88.2 feet (26.9 m), and stand density (tree canopy density), 71 %, that would be established in the riparian area. If it is difficult to determine the streams aspect from north, the average stream aspect from north, black line, can be used to determine the solar radiation loading and effective shade.

Conclusion: A land owner or manager living on the west side of the Willamette River near the city of Independence, measures the channel width of the tributary stream as 25 feet (8 m), with a stream aspect from north of 0º or 180º. By using the geomorphic map for shade curve development that is specific to the areas watershed, provided by ODEQ, in this case Rickreall Creek Watershed geomorphic map. The land owner identifies their location and the corresponding geomorphic unit as Qalc in this example. The land owner then uses the Qalc shade curve to identify what the effective shade and solar radiation loading reaching the stream would be when the land owner establishes a riparian area corresponding to the system potential vegetation description. This is considered the nonpoint source load allocation.

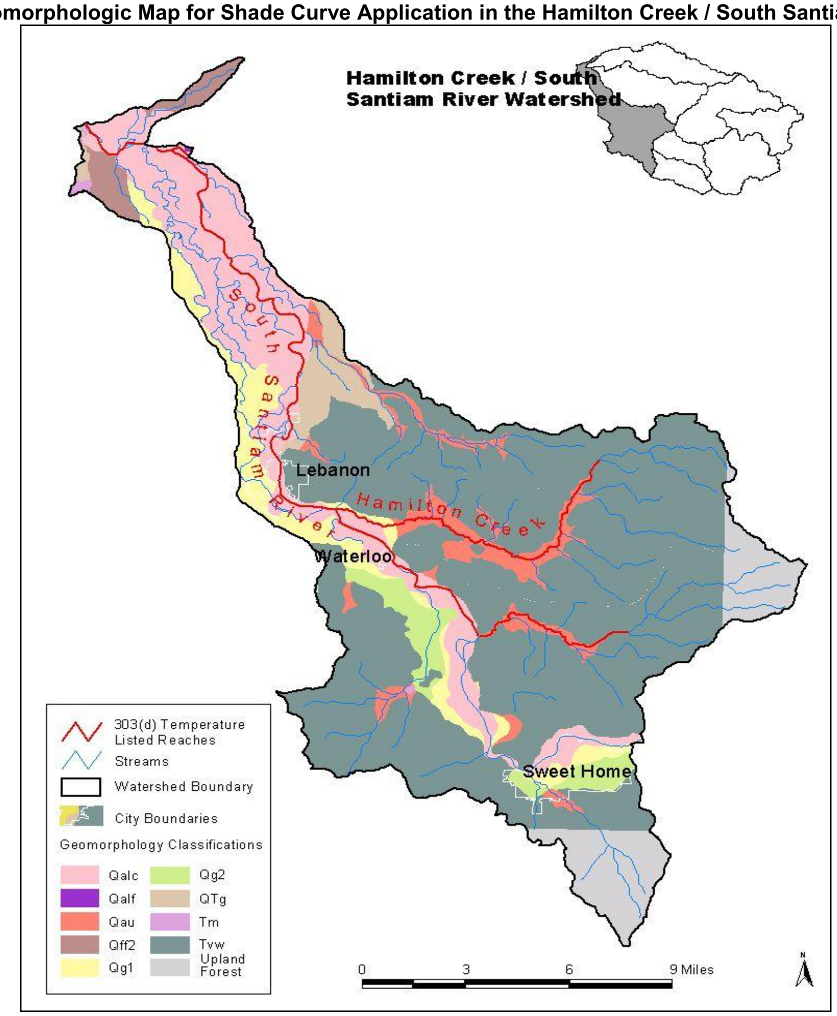
Map 9.8 Geomorphologic Map for Shade Curve Application in the South Santiam Subbasin.



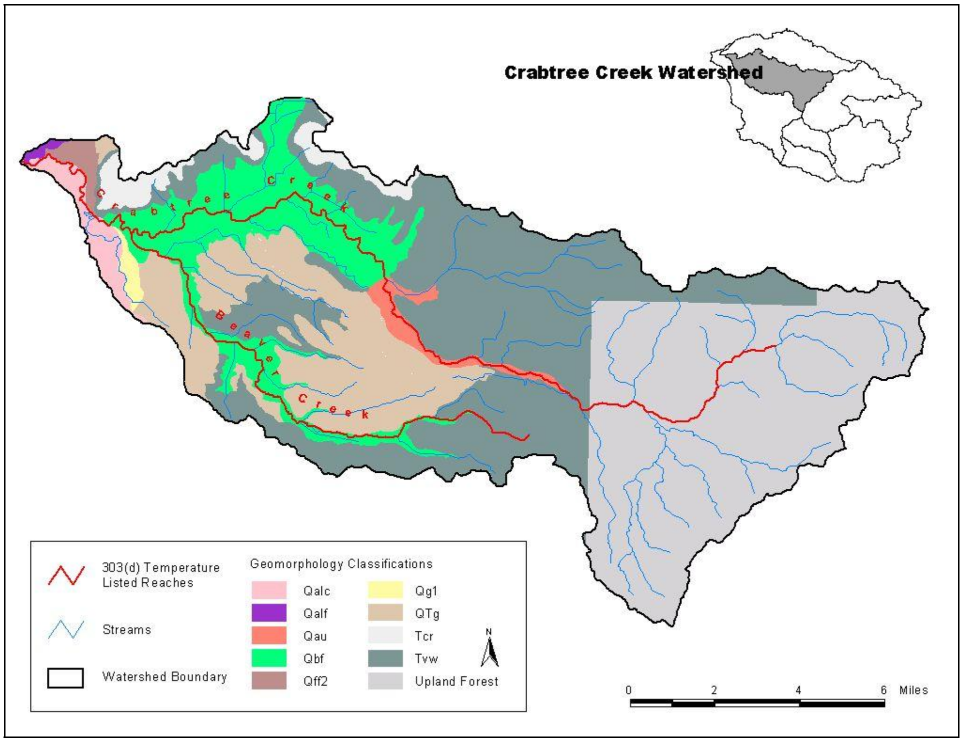
Map 9.9 Geomorphologic Map for Shade Curve Application in the South Santiam Watersheds



Map 9.10 Geomorphologic Map for Shade Curve Application in the Hamilton Creek / South Santiam Watershed.

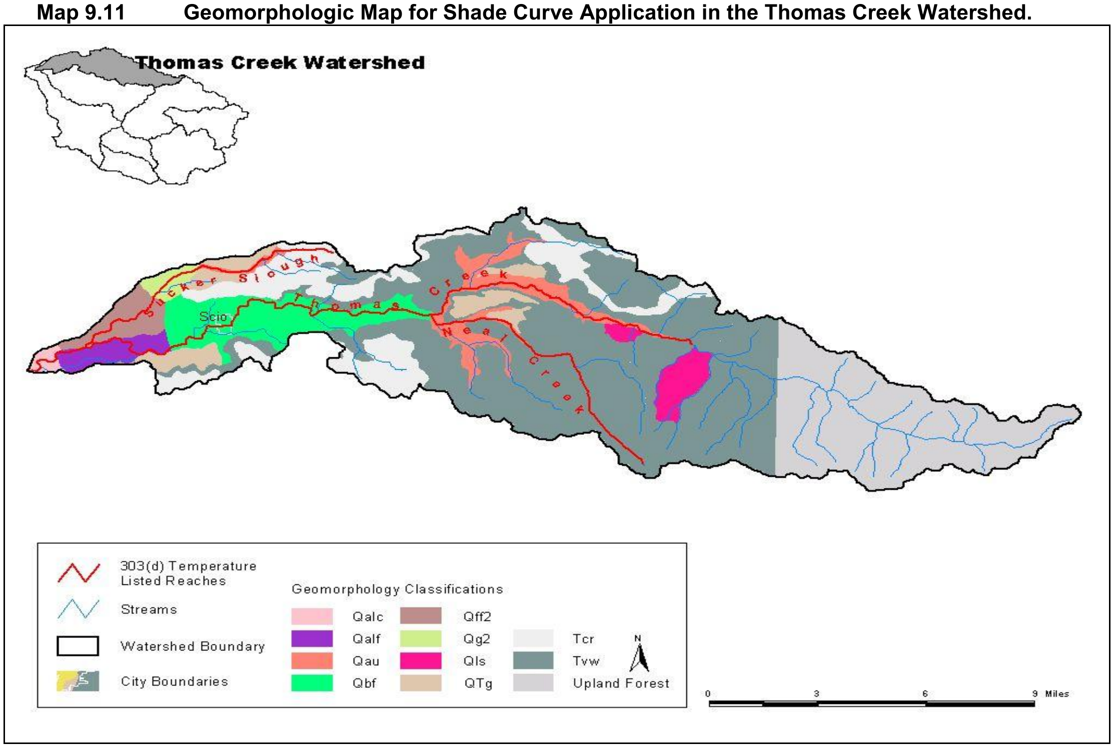


Geomorphologic Map for Shade Curve Application in the Crabtree Creek Watershed.

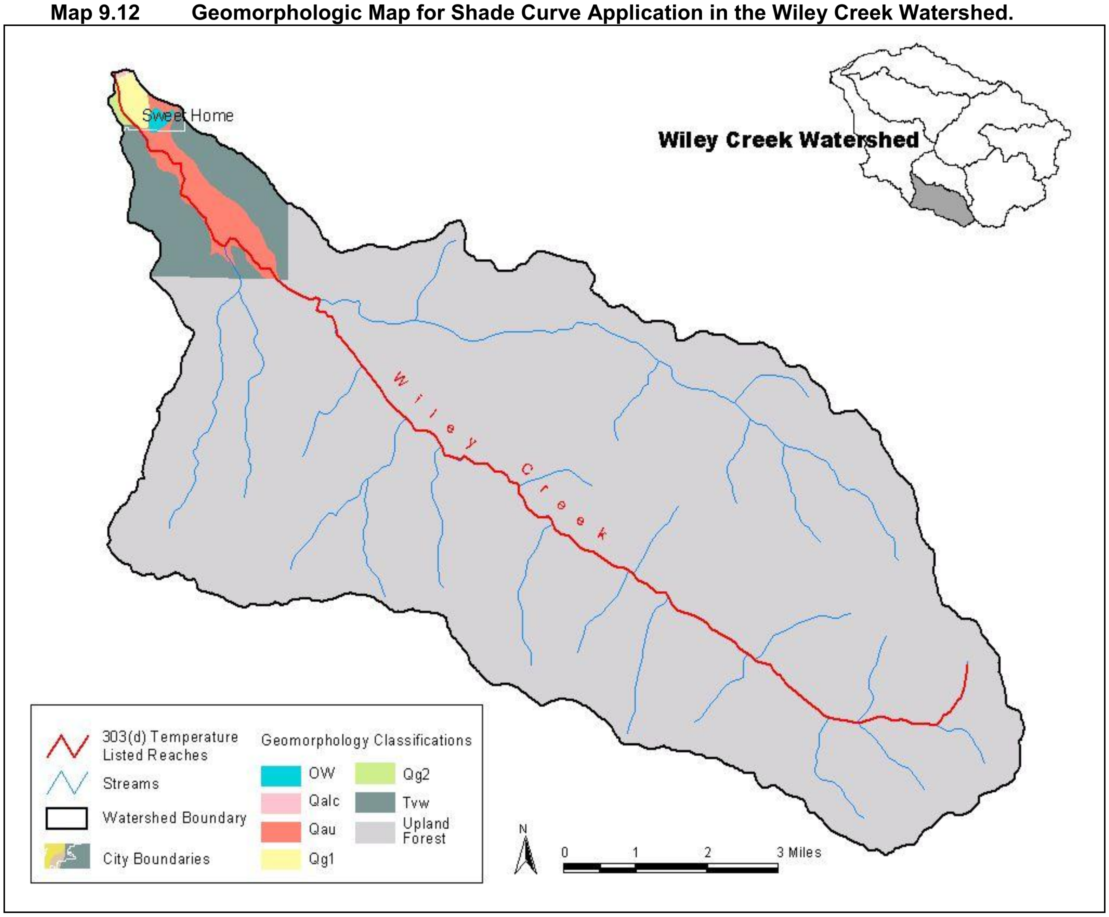


Crabtree Creek Watershed
Crabtree Creek
Beaver Creek
303(d) Temperature Listed Reaches
Streams
Watershed Boundary
Geomorphology Classifications
Qalc
Qalf
Qau
Qbf
Qff2
Qg1
QTg
Tcr
Tvw
Upland Forest
N
0
2
4
6
Miles

Map 9.11 Geomorphologic Map for Shade Curve Application in the Thomas Creek Watershed.



Map 9.12 Geomorphologic Map for Shade Curve Application in the Wiley Creek Watershed.



The shade curve method provides no information on existing shade conditions or the expected system potential stream temperature. It does provide quick and accurate estimates of the allocations necessary to eliminate temperature increases resulting from anthropogenic impacts on stream shading. The shade curves presented in Figure 9.11 apply to all water bodies in the South Santiam Subbasin based on the geomorphic and upland forest unit of the reach. The shade curves represented in each figure have been calculated based on the average height for each unit as defined by system potential vegetation. Interpretation and implementation of the shade curves requires the identification of the geomorphic or upland forest unit that applies to the stream reach (Map 9.8 to 9.12), measuring the stream's channel width and then depending on the stream's aspect from north reading the shade curves graph to determine the percent effective shade and solar radiation loading that the system potential vegetation composition will provide. For a list of geomorphic class abbreviations for each shade curve please see Table 9.8, above.

Geomorphic unit code Pre Flood Quaternary Sand/Gravel (Qg2) is represented in the South Santiam Subbasin. The shade curve for Qg2 has not been developed. Historically the geomorphic unit code Qg2 had 90% prairie vegetation along streams that historically became subsurface in the summer and for which water is currently artificially diverted to maintain summer flows. Historic vegetation is probably not a good guideline for modeling potential present day stream temperature. Instead, ODEQ will use the nearest adjacent geomorphic code as determined by the geomorphologic maps, Map 9.8 to 9.12.

Figure 9.11 **Shade Curves that apply to the South Santiam Subbasin, based on geomorphology.**

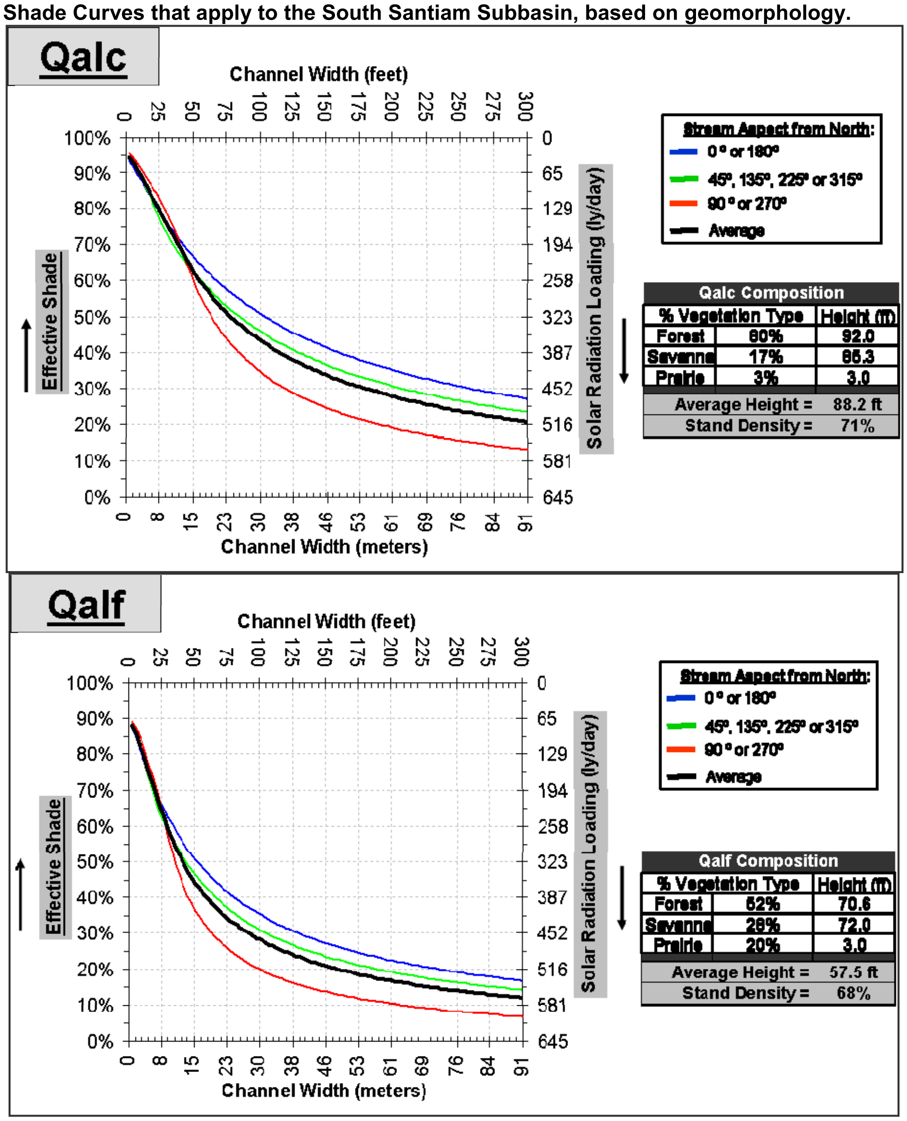


Figure 9.11 cont.

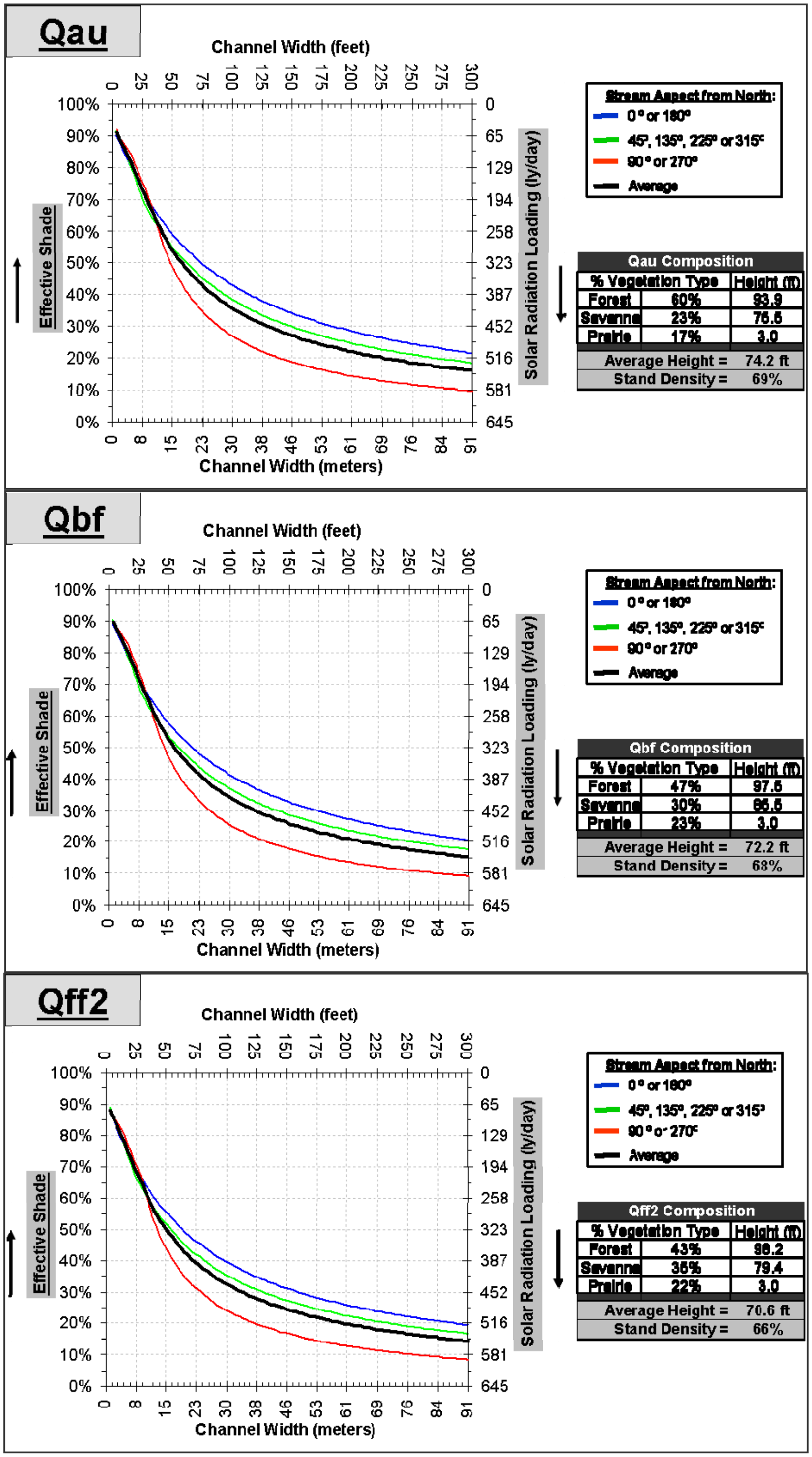
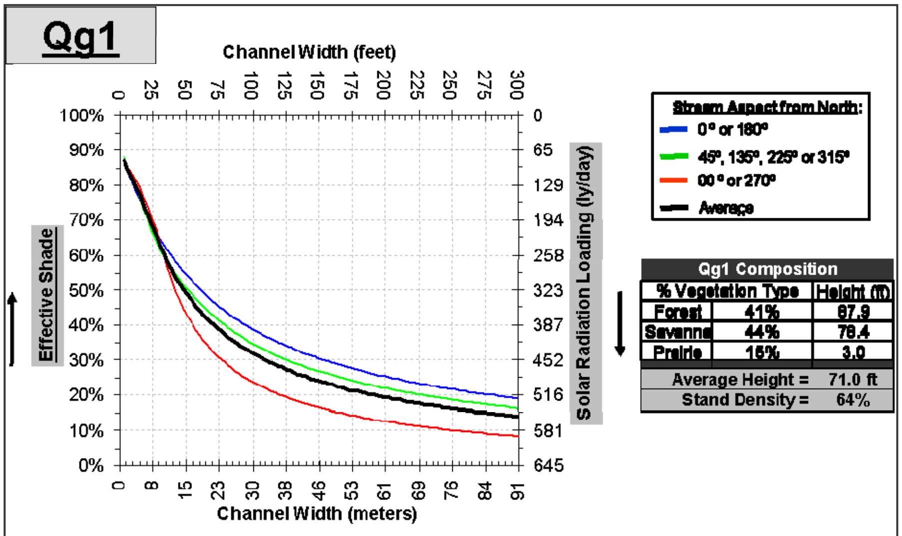
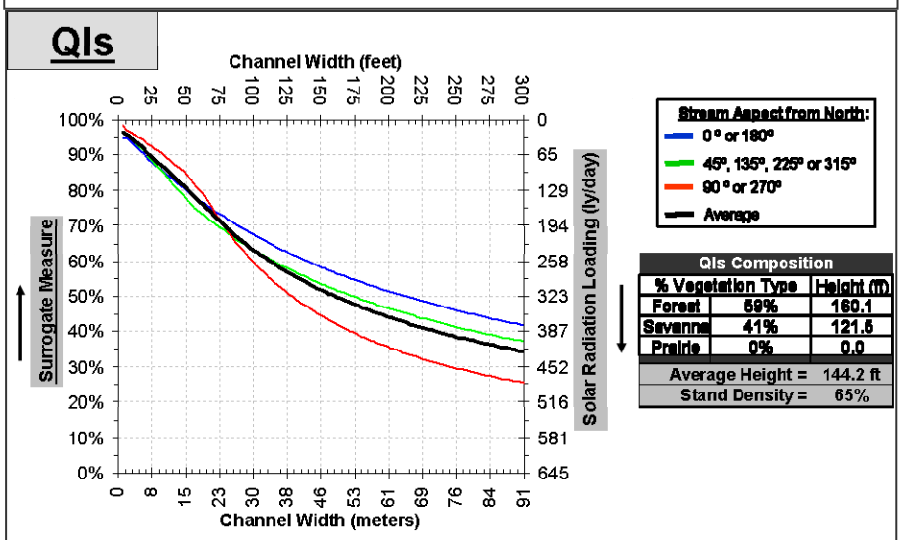


Figure 9.11 cont.





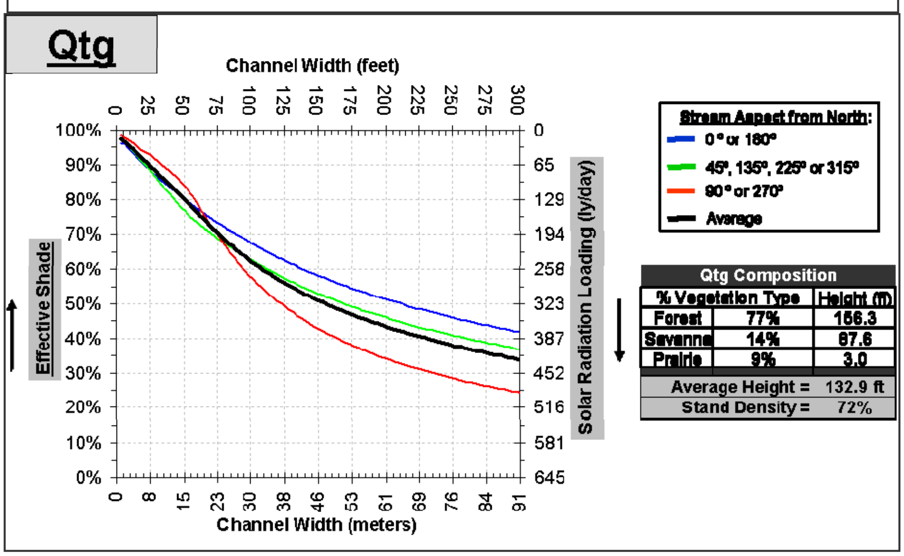


Figure 9.11 cont.

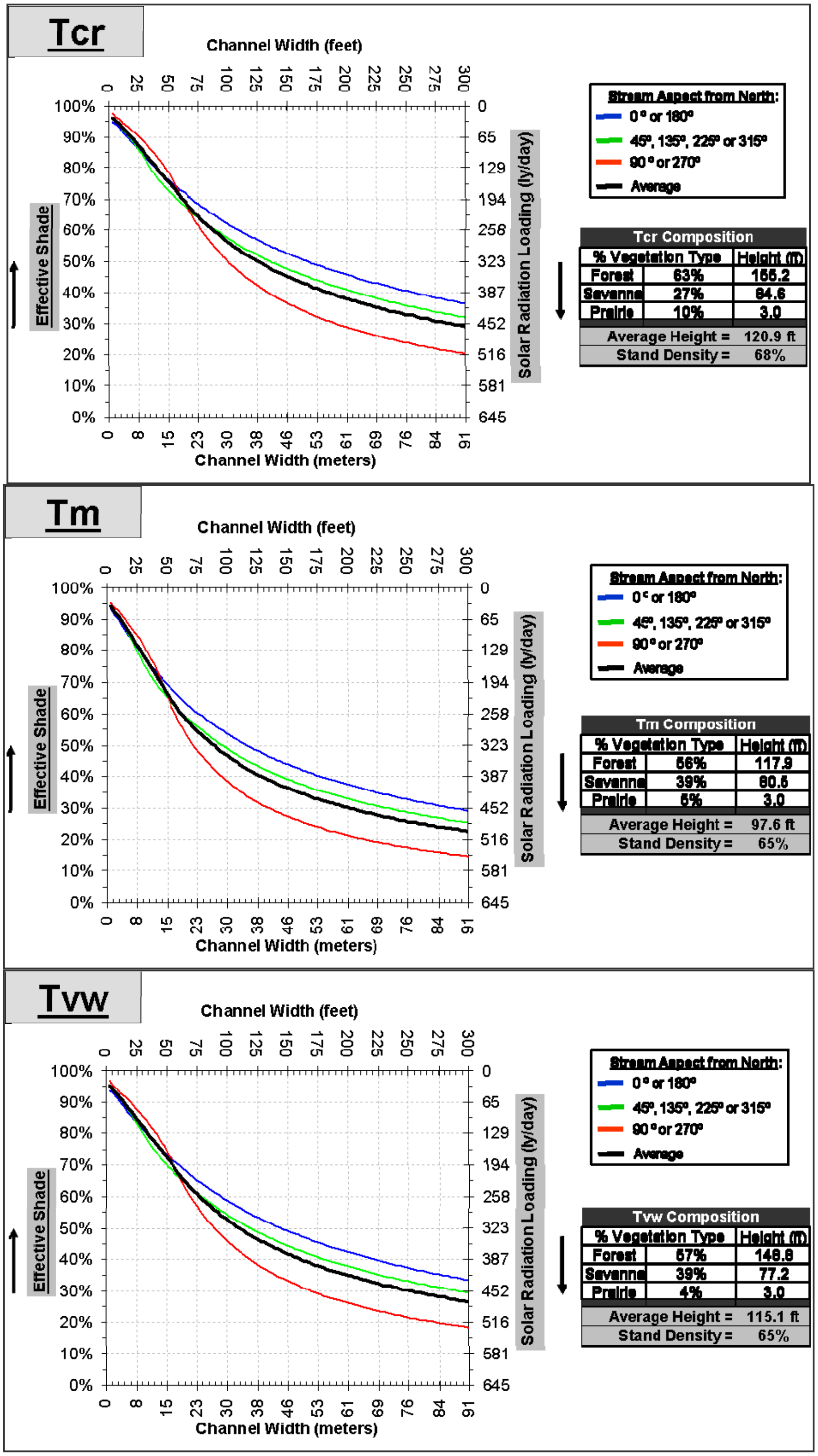
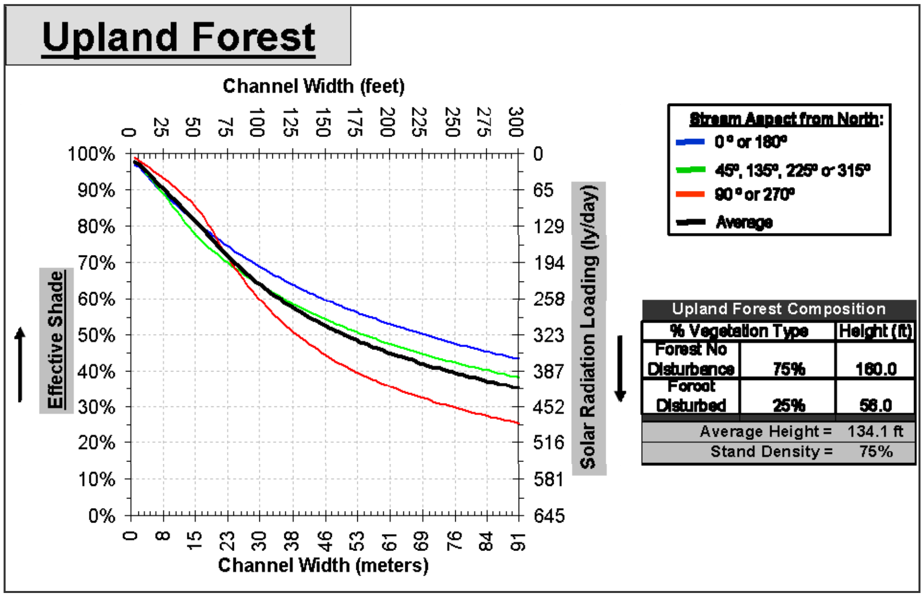


Figure 9.11 cont.



Margin of Safety

OAR 340-042-0040(4)(i), CWA 303(d)(1)

A margin of safety is intended to account for uncertainty in available data or in the effect controls will have on loading reductions and water quality. A margin of safety is expressed as unallocated assimilative 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 margin of safety may be implicit, as in conservative assumptions used in calculating the Loading Capacity, Wasteload Allocations, and Load Allocations. It may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources. Table 9.9 presents six approaches for incorporating a margin of safety into TMDLs.

The following factors may be considered in evaluating and deriving an appropriate MOS:

- ✓ *The analysis and techniques used in evaluating the components of the TMDL process and deriving an allocation scheme.*
- ✓ *Characterization and estimates of source loading (e.g., confidence regarding data limitation, analysis limitation or assumptions).*
- ✓ *Analysis of relationships between the source loading and instream impact.*
- ✓ *Prediction of response of receiving waters under various allocation scenarios (e.g., the predictive capability of the analysis, simplifications in the selected techniques).*
- ✓ *The implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.*

A TMDL and associated margin of safety, which results in an overall allocation, represent the best estimate of how standards can be achieved. The selection of the margin of safety should clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation-planning component.

Table 9.9 Approaches for Incorporating a Margin of Safety into a TMDL

Type of Margin of Safety	Available Approaches
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for margin of safety.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

A margin of safety has been incorporated into the temperature assessment methodology. Wasteload allocations are based on critical conditions that are unlikely to occur simultaneously. For example, it is unlikely that maximum effluent flows and maximum effluent temperatures are likely to occur simultaneously however those values were used to calculate point source heat loads. Furthermore, receiving stream values were also based on attainment of biological based criteria during low flow periods defined as the low flow of a ten year cycle.

Calculating a numeric margin of safety for nonpoint source loads is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and load allocations is system potential conditions and it is not the purpose of this plan to promote riparian conditions and shade levels that exceed natural conditions.

Reserve Capacity

OAR 340-042-0040(4)(k)

Reserve capacity has been allocated for temperature through much of the Willamette Basin. Explicit allocations have generally only been made in conjunction with point source wasteload allocations. Where there are multiple point sources in a water body, point sources in combination have been allocated 0.2˚C of the human use allowance. Another 0.05˚C is allocated to nonpoint sources of heat. These latter sources have generally been limited to natural solar radiation levels determined by shade curves for a given area. The final 0.05˚C is allocated to reserve capacity, and will be available for use by point sources or nonpoint sources by application to ODEQ. In total, these allocations may not increase temperature in a water quality limited water body by more than 0.3°C (0.54°F) at the point of maximum impact.

In those situations where the point source allocation is less than 0.2˚C or if there are no point sources, the remaining portion of the human use allowance will be set aside as reserve capacity. The nonpoint source allocation will remain at 0.05˚C unless special circumstances exist that require a larger or smaller allocation. More information regarding the use of reserve capacity may be found in Chapter 14, Water Quality Management Plan, Part 2, under Temperature Implementation.

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