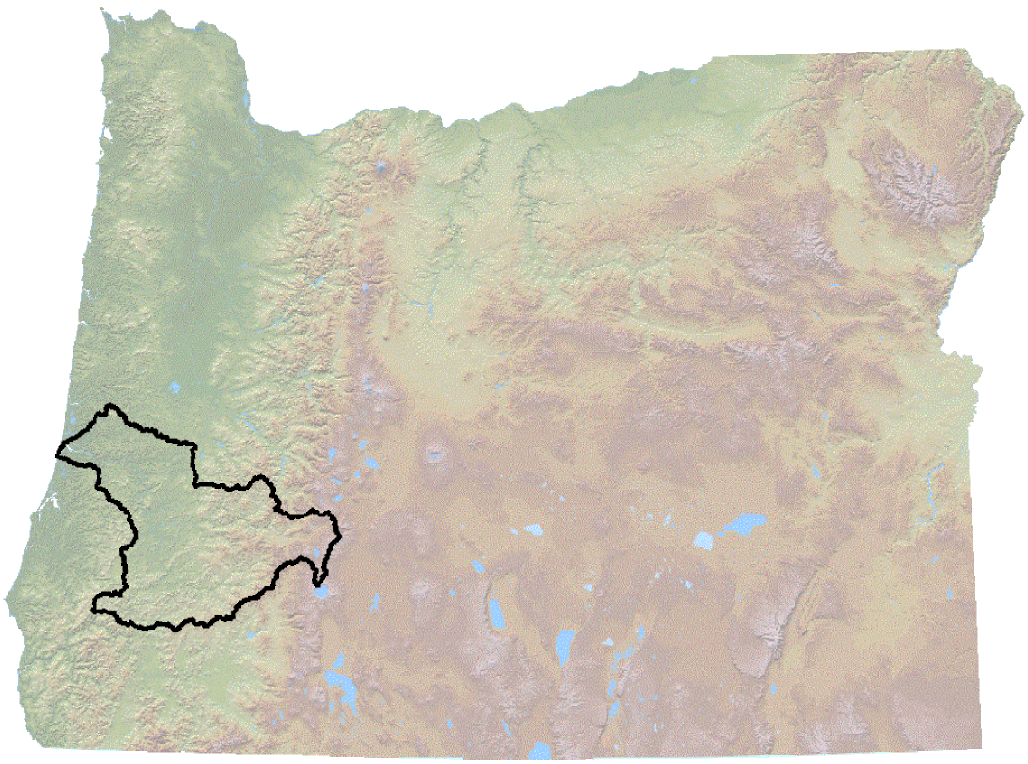
CHAPTER 3
UMPQUA BASIN
STREAM TEMPERATURE TMDL



State of Oregon
Department of Environmental Quality

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Definitions

Anthropogenic Nonpoint Source Heat Load: Heat load caused by human activities.

Anthropogenic Nonpoint Source Load Allocation: The amount of heat that anthropogenic nonpoint sources may contribute to a stream without exceeding the applicable criteria. It includes the human use allowance.

Assimilative Capacity: The amount of heat above the background level that a waterbody can receive without exceeding water quality standards. Assimilative capacity gets divided amongst nonpoint source load allocations and point source waste load allocations.

Background Heat Load: The amount of heat that a stream would naturally receive in the absence of all anthropogenic impacts. It includes heat load from natural disturbances.

Bypass Reach: The original or natural stream channel downstream of hydro project dams or withdrawals.

Current Total Heat Load: The amount of heat load a stream currently receives from all sources; including anthropogenic nonpoint sources, point sources, and background (including natural disturbance).

Effective Shade: The percent reduction of potential daily solar radiation load delivered to the stream surface.

Heat Flux: The amount of heat per unit time per unit area (e.g. watts per square meter) measured at the stream surface.

Heat Load: The amount of heat received per 24-hour period by the stream (e.g. megawatts). It is calculated by multiplying the stream surface area by the solar heat flux.

Human Use Allowance: Allowable anthropogenic heat load equivalent to a cumulative 0.3^{o}C increase above the applicable criteria at the point(s) of maximum impact.

Natural Thermal Potential (NTP): "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. (OAR 340-041-0002)

Nonpoint Source Loading Capacity: The amount of heat that a stream can receive from nonpoint sources (natural and anthropogenic) without exceeding the applicable criteria.

Point of Maximum Impact: The location in a stream where the cumulative impacts of all upstream sources is most severe or most critical. The point of maximum impact may vary seasonally as well as spatially. Some water bodies may have more than one point of maximum impact, depending on the unique spatial and temporal thermal profiles of that water body.

3.1 OVERVIEW AND SCOPE

Human activities and aquatic species protected by water quality standards are called “beneficial uses”. Water quality standards are developed to protect the most sensitive beneficial use within a waterbody. Oregon’s stream temperature standard is designed to protect cold water fish (salmonids) rearing and spawning as the most sensitive beneficial use.

Oregon’s stream temperature standard is both numeric and narrative. Numeric triggers are based on temperatures that protect various salmonid life stages. Narrative triggers specify conditions that deserve special attention, such as outstanding resource waters and dissolved oxygen violations.

When stream temperature data indicates a standard violation, the waterbody is designated water quality limited and placed on the 303(d) list. Total Maximum Daily Loads (TMDLs) must then be completed for the 303(d) listed waterbodies.

This temperature TMDL applies to all perennial and fish bearing streams within the Umpqua River Basin, with the exception of those within the Little River Watershed where a TMDL was completed and approved by EPA in 2002[1]. Figure 3.1 shows the Umpqua River basin, its 3 subbasins, and the Little River Watershed. The Little River Watershed is part of the North Umpqua Subbasin.

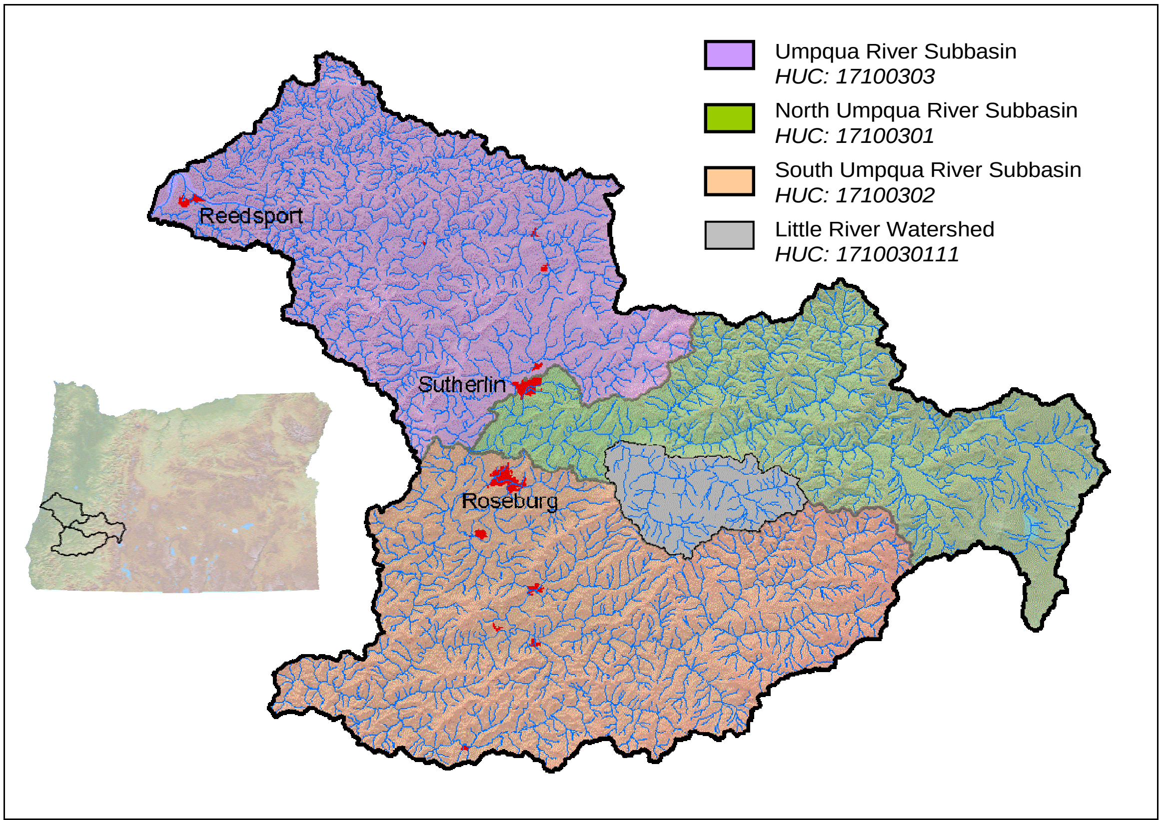

Figure 3.1 The Umpqua River Basin includes three subbasins (4th field hydrologic units).

[1] The Little River Watershed TMDL can be downloaded from http://www.deq.state.or.us/WQ/TMDLs/UmpquaBasin.htm.

Stream temperatures were simulated using a computer model (Heat Source) for the main rivers and their larger tributaries (Table 3.1). Simulations focus on the larger streams that contain or influence primary fish habitat. Site-specific load allocations have been developed for the streams that were simulated. Other streams are assigned generalized load allocations based on potential vegetation and effective shade curves (**see Section 3.5**).

Table 3.1 Stream Temperature Simulation Extents

River/Stream	Simulation Extent
Jackson Creek	Falcon Creek to Mouth
Cow Creek	Galesville Reservoir to Mouth
Olalla-Lookingglass Creek	Berry Creek to Mouth
South Umpqua River	Castle/Black Rock Forks to Mouth
Lake Creek	Diamond Lake to Mouth
Clearwater River	Stump Lake to Mouth
Fish Creek	Clear Creek to Mouth
North Umpqua River (upper)	Lemolo Reservoir to Steamboat Creek
Canton Creek	Pass Creek to Mouth
Steamboat Creek	Little Rock Creek to Mouth
Rock Creek	Northeast Rock Creek to Mouth
Cavitt Creek	Cultus Creek to Mouth
Little River	Hemlock Creek to Mouth
North Umpqua River (lower)	Steamboat Creek to Mouth
Calapooya Creek	North Fork Calapooya River to Mouth
Elk Creek	Wise Creek to Mouth
Umpqua River	Forks to Tidewater
North Fork Smith River	Kentucky Creek to River Mile 5.2
West Fork Smith River	River Mile 11.5 to Mouth
Smith River	Peterson Creek to Johnson Creek
	Total Simulation Extent: 650 stream miles

IMPORTANT NOTE: Little River and Cavitt Creek are located within the Little River Watershed, where a TMDL was approved by EPA in 2002. This TMDL does not replace the Little River Watershed TMDL. Little River and Cavitt Creek were simulated during development of the Umpqua River Basin TMDL in order to include their thermal influences on the rest of the stream network modeled (i.e., to quantify their effects on the North Umpqua River).

This temperature TMDL addresses rearing/migration and spawning period temperature impairments on streams without point sources or dams for the entire basin. In rivers that have no point sources or dams, activities designed to improve summer stream temperatures are the same activities that will improve fall and winter temperatures. The nonpoint source load allocations are expressed as effective shade targets and apply year-round.

Furthermore, this temperature TMDL addresses streams with point sources and dams during the rearing/migration (i.e. non-spawning) time period. Waste load allocations have been developed for point sources during the portion of the year when spawning does not occur and will be incorporated into the NPDES permits. During the spawning period, there are three impaired segments on the North Umpqua River that are downstream of a hydro-electric project and a point source is present. More data and analysis are needed to complete those TMDLs. Likewise, on other steams and rivers that are not currently identified as impaired during the spawning period and have point sources or dams, the TMDLs were not computed.

The **Umpqua River Basin Temperature TMDL Appendix** contains more detailed information regarding data sources, analytical methodology, and simulation results.

3.1.1 Stream Temperature TMDL Approach Summary

Stream temperature TMDLs are generally scaled to a subbasin or basin and include all perennial surface waters that have salmonid presence or that contribute to areas with salmonid presence. Since stream temperatures are affected by cumulative interactions between upstream and local sources, the TMDL considers all surface waters that affect the temperatures of 303(d) listed waterbodies. For example, the North Umpqua, South Umpqua, and Umpqua Rivers are water quality limited for temperature. To address these listings in the TMDL, all major tributaries are included in the TMDL analysis and TMDL allocations are applied throughout the entire stream network.

An important step in the TMDL is to perform a source assessment which quantifies the anthropogenic contributions to stream heating. One anthropogenic contribution to solar radiation heat loading results from decreased stream surface shade. Decreased stream shade may be caused by near stream vegetation disturbance/removal and channel morphology changes. Other anthropogenic sources of stream warming may include stream flow reductions and warm water point source effluent.

Heat is the identified pollutant. Anthropogenic nonpoint and point sources are not permitted to heat a waterbody more than 0.3°C above the applicable criteria, cumulatively at the point of maximum impact. Allocated conditions are expressed as solar heat load and solar heat flux (watts, and watts per square meter, respectively). Nonpoint source heat allocations are translated into effective shade surrogate measures. Effective shade surrogate measures provide site-specific targets for land managers. Attainment of the surrogate measures ensures compliance with the nonpoint source allocations. Point source waste load allocations are based on the applicable numeric and/or narrative criteria. Point sources are not allowed to increase stream temperatures more than 0.1°C (a portion of the 0.3°C human use allowance) cumulatively at the point of maximum impact.

Table 3.2 summarizes the components of this TMDL.

Table 3.2 Umpqua Basin Temperature TMDL Components

Beneficial Uses **OAR 340-042-0040(4)(c)** **OAR 340-41**	Salmonid fish spawning and rearing, anadromous fish passage, resident fish and aquatic life, and fishing are the most sensitive beneficial uses. See **Table 3.3** for a complete list.
Waterbodies **OAR 340-042-0040(4)(a)**	Perennial and fish bearing (as identified by ODFW, USFW or NOAA Fisheries) streams within the Umpqua River basin, HUC (Hydrologic Unit Code) 17100301, 17100302, and 17100303. *Excludes the Little River watershed, HUC 1710030111 where a TMDL was approved by EPA in 2002.*
Pollutant Identification **OAR 340-042-0040(4)(b)**	<u>*Pollutants:*</u> Anthropogenic heat from (1) warm water discharges to surface waters, (2) increased solar radiation loading, and (3) flow modifications that affect natural thermal regimes.
Seasonal Variation **OAR 340-042-0040(4)(j)** **CWA §303(d)(1)**	Peak temperatures occur in June, July, August, and September.
Target Identification **(Applicable Water Quality Standards)** **OAR 340-042-** **CWA §303(d)(1)**	OAR 340, Division 41 provides numeric and narrative temperature criteria. Maps and tables provided in OAR 340-041-0101 to 0340 specify where and when the criteria apply. Biologically based numeric criteria applicable to the Umpqua River basin, as measured using the seven-day average maximum stream temperature, include: 12.0°C during times and at locations of bull trout spawning and juvenile rearing. 13.0°C during times and at locations of salmonid 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. 20.0°C during times and at locations of salmon and steelhead migration in identified migration corridors with sufficiently distributed coldwater refugia. There are additional narrative criteria that apply within the Umpqua River basin such as the cool water species, antidegradation and human use allowance narratives. Refer to the OAR for details.

Existing Sources **OAR 340-042-0040(4)(f)** **CWA §303(d)(1)**	Nonpoint sources include excessive inputs of solar radiation because of streamside vegetation removal or reduction, anthropogenic channel degradation, and flow modifications. Point sources include municipal and industrial facilities that discharge warm water to receiving streams.
Surrogate Measures **OAR 340-042-0040(5)(b)** **40 CFR 130.2(i)**	Surrogate measures are used throughout the temperature TMDL. Effective shade targets translate nonpoint source solar radiation loads into stream side vegetation objectives.
Water Quality Standard Attainment Analysis **CWA §303(d)(1)**	Analytical modeling of TMDL loading capacities (stream temperature modeling) demonstrates attainment of water quality standards. See Chapter 7 for the Water Quality Management Plan.
TMDL **Loading Capacity and Allocations** **OAR 340-042-0040(d), (e), (g), and (h)** **40 CFR 130.2(f)** **40 CFR 130.2(g)** **40 CFR 130.2(h)**	*Loading Capacity:* OAR 340-041-0028(12)(b)(B) states anthropogenic heat sources may increase stream temperature no more than 0.3°C (0.5°F) above the applicable biological criteria or the natural condition criteria. This is achieved when the cumulative heat input of all point and nonpoint sources results in no greater than a 0.3°C increase in temperature above the criteria at the point of maximum impact. Loading capacity is the heat load that corresponds to the applicable criteria plus the 0.3°C human use allowance. *Excess Load:* The difference between the actual pollutant load and the loading capacity of the waterbody is the excess load. Excess load in this TMDL is the difference between heat loads that meet applicable temperature criteria plus the human use allowance and current heat loads. *Load Allocations (Nonpoint Sources):* Natural background heat loads from solar radiation are the targeted load allocation. A portion (0.1°C) of the human use allowance has been allocated to nonpoint source activities to address anthropogenic heat loads in excess of background rates. This human use allowance is for anthropogenic heat loads in landscapes that are not likely to achieve a natural condition. *Waste Load Allocations (Point Sources)*: Waste load allocations are based on allowing no greater than a 0.1°C (portion of the human use allowance) increase in stream temperature above the applicable temperature criteria at the point of maximum impact.
Reserve Capacity **OAR 340-042-0040(4)(k)**	A portion (0.1°C) of the human use allowance is allocated to reserve capacity for future sources.
Margins of Safety **OAR 340-042-0040(4)(i)** **CWA §303(d)(1)**	*Margins of safety* are demonstrated in critical condition assumptions used for point source waste load allocations and are inherent within the nonpoint source load determination methodology.
Water Quality Management Plan **OAR 340-042-0040(4)(l)** **CWA §303(d)(1)**	The Water Quality Management Plan (WQMP) provides the framework of management strategies designed to attain and maintain water quality standards. The framework is designed to work in conjunction with detailed plans and analysis provided in specific implementation plans.

3.1.2 Beneficial Use Identification

Water quality standards include designation of beneficial uses, numeric and narrative criteria for individual parameters to protect those uses, and antidegradation policies to protect overall water quality. Beneficial uses and the associated water quality criteria are generally applicable throughout the basin. Some uses such as salmonid spawning have been further delineated to ensure the appropriate application of numeric and narrative criteria. These criteria are intended to protect the most sensitive beneficial uses (Table 3.3).

Salmon, trout and other cold water species that inhabit most streams in the Umpqua River Basin are considered the beneficial uses most sensitive to stream temperature. Biologically-based numeric criteria were developed that are specific to salmonid life stages such as spawning and rearing. Criteria were also developed for critical habitat areas that serve as the core for salmonid protection and restoration efforts. The complete Oregon temperature rule (OAR 340-041-0028) can be accessed at http://www.deq.state.or.us.

Table 3.3 Beneficial uses occurring in the Umpqua River Basin (OAR 340-041-0320)

Temperature-Sensitive Beneficial uses are marked in **Gray**					
Beneficial Uses	**Umpqua R. Estuary to Head of Tidewater & Adjacent Marine Waters**	**Umpqua R. Main from Head of Tidewater to Confluence of N. and S. Umpqua Rivers**	**North Umpqua River Mainstem**	**South Umpqua River Mainstem**	**All Other Tributaries to Umpqua, North & South Umpqua Rivers**
Public Domestic Water Supply[1]		X	X	X	X
Private Domestic Water Supply[1]		X	X	X	X
Industrial Water Supply	X	X	X	X	X
Irrigation		X	X	X	X
Livestock Watering		X	X	X	X
Fish & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power			X	X	X
Commercial Navigation & Transportation	X				
[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.					

3.1.3 Target Identification - Applicable Water Quality Standards

The water quality standard for temperature is contained in OAR 340-0411-0028. Biologically-based numeric stream temperature criteria are expressed as a seven-day average maximum temperature. Table 3.4 summarizes the numeric temperature criteria that are applicable to specific salmonid life stages..

Oregon water quality standards include provisions for periods and locations where biologically-based numeric criteria may not be achieved. If biologically-based numeric criteria are not achievable when waters are in their natural condition, stream temperatures achieved under natural conditions shall be the temperature criteria for that water body. In other words, a stream that does not meet the biologically-based numeric temperature criteria, but is free from anthropogenic influence is considered at its natural thermal potential. In these situations the natural thermal potential temperatures supersede the biological numeric criteria and are considered the applicable numeric criteria. Unlike the biologically-based criteria such as the rearing criterion of 18°C, which is constant for the entire summer period, the natural thermal potential is site specific and varies over time. TMDLs attempt to quantify the natural thermal potential of major streams through computer modeling.

Oregon water quality standards also have provisions for human use. The human use allowance limits cumulative anthropogenic heating of surface waters to no more than 0.3°C (0.5°F) above the applicable biological or natural conditions criteria at the point of maximum impact. Again, the metric for compliance is a seven-day average maximum temperature.

Among the antidegradation policies included in Oregon water quality standards, are provisions to prevent the unnecessary degradation of high quality water and to ensure full protection of all existing beneficial uses. At a minimum, uses are considered attainable wherever feasible or wherever attained historically. Antidegradation policies generally apply when ambient water temperatures are less than the numeric criteria and offer provisions that allow for some degradation in water quality provided that such degradation does not prevent attainment of standards or negatively impact beneficial uses.

Oregon water quality standards also specify where and when the specific salmonid life stages occur and, therefore, where and when numeric criteria apply. Salmonid distribution and timing maps are provided in Figures 3.2 and 3.3 on the following pages.

Table 3.4 Biologically-Based Numeric Temperature Criteria

Use	Numeric Criteria (7-Day Average Maximum)
Salmon and Steelhead Spawning	13.0°C/55.4°F
Core Cold Water Habitat	16.0°C/60.8°F
Salmon and Trout Rearing and Migration	18.0°C/64.4°F
Salmon and Steelhead Migration Corridors	20.0°C/68.0°C
Lahontan Cutthroat or Redband Trout Use	20.0°C/68.0°C

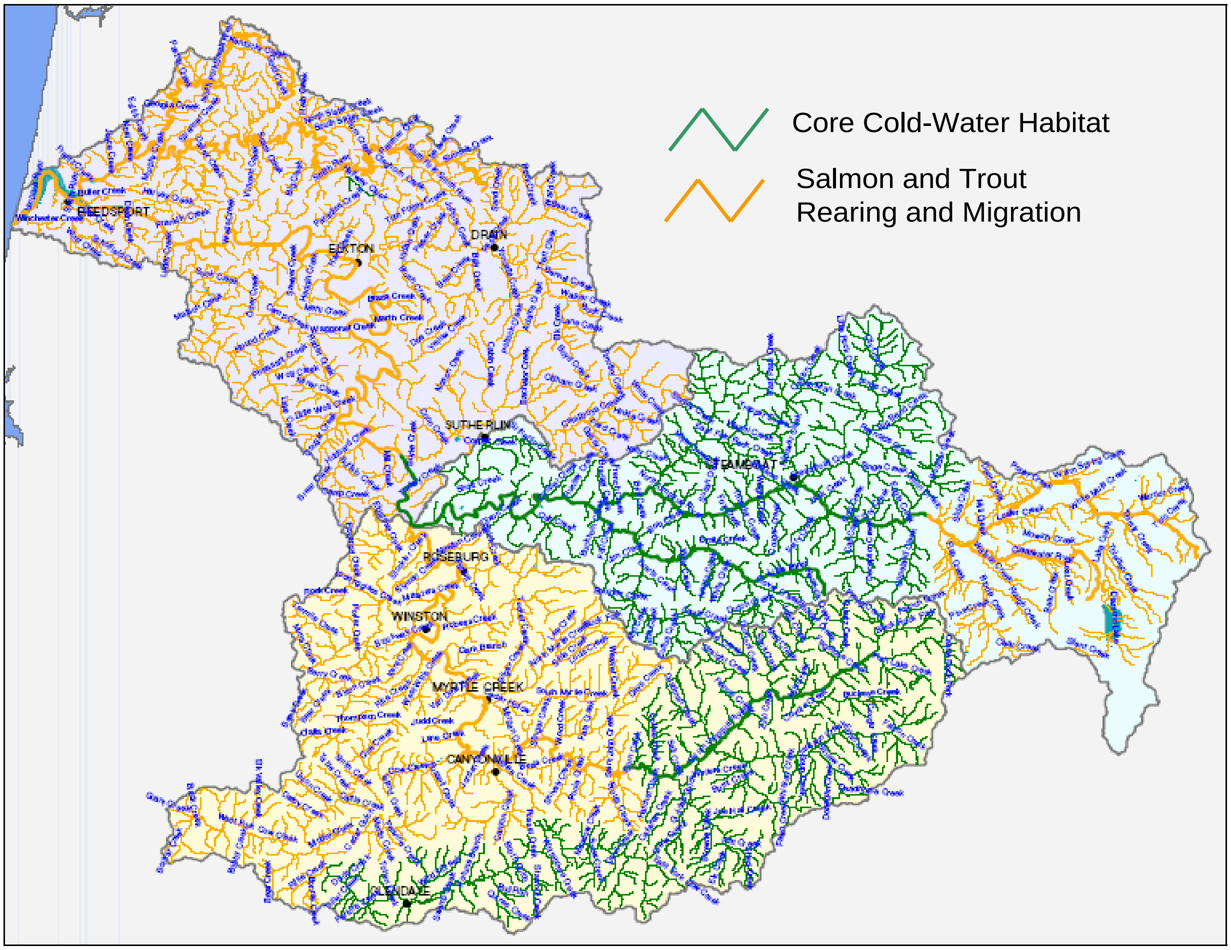

Figure 3.2 **Fish Use Designations (map from OAR 340-041-0028, Figure 320A).**

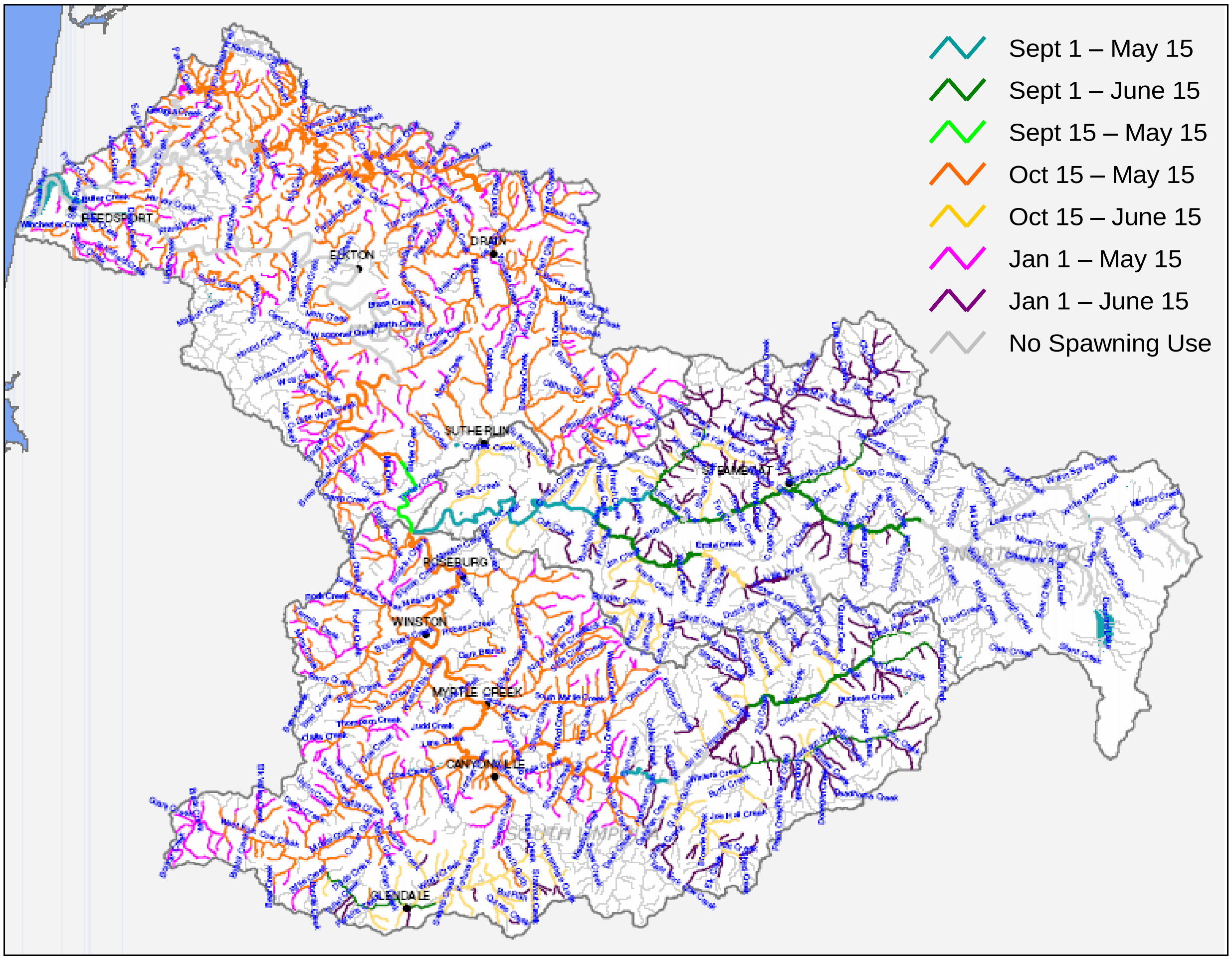

Figure 3.3 Salmon and Steelhead Spawning Use Designations (*map from OAR 340-041-0028, Figure 320B*).3.1.4 Waterbodies Listed for Temperature

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies which violate water quality standards, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list[2].

The Umpqua River basin has 180 individual temperature listings on the 2002 303(d) list. Some streams may have more than one temperature listing. For example, Calf Creek in the North Umpqua River subbasin is listed for exceeding the summer rearing criteria *and* the spawning criteria. Figure 3.4 highlights the streams on the 2002 303(d) list for temperature.

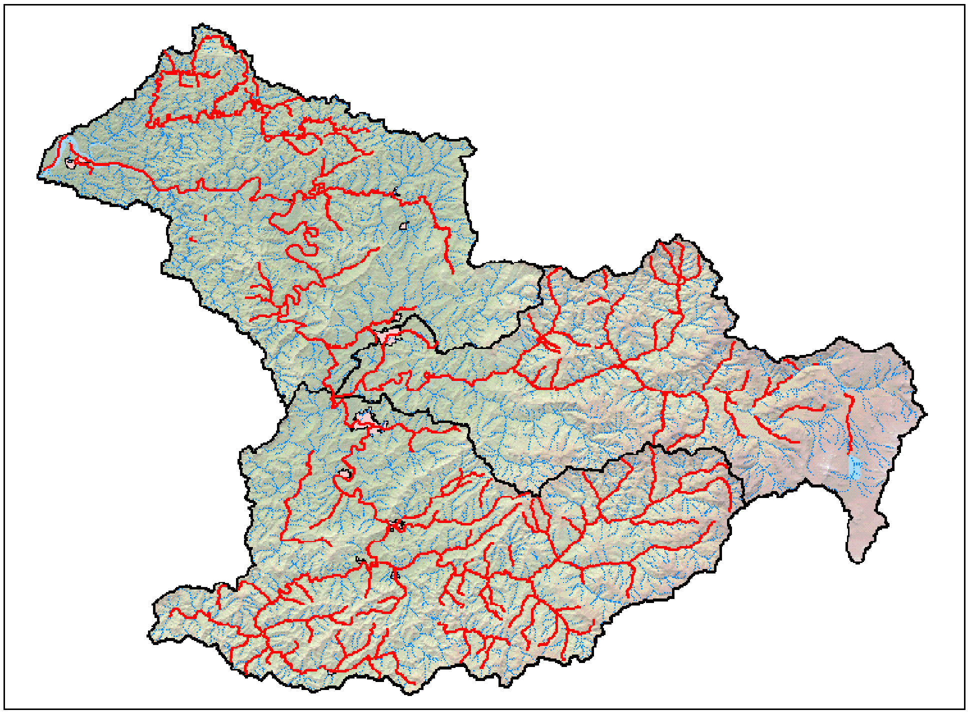

Figure 3.4 2002 303(d) List for Temperature (Bolded Red Lines)

3.1.5 Pollutant Identification

Anthropogenic heat sources are derived from solar radiation as increased levels of sunlight reach the stream surface and effluent discharges to surface waters. Therefore, the pollutants targeted in this TMDL are:

Anthropogenic Nonpoint Source: Heat from human-caused solar radiation loading increases to the stream network, as a result of alterations in near stream vegetation, channel morphology, and flow modifications.

Anthropogenic Point Source: Heat from warm water discharges of human origin, such as industrial outfalls, waste water treatment plants, and other point sources.

3.1.6 Seasonal Variation & Critical Condition

One TMDL requirement is the identification of seasonal variation and the critical condition. The warmest stream temperature typically occurs in July and August (Figure 3.5). The TMDL focuses the analysis during July as a critical condition for nonpoint sources as identified by 2000, 2001, and 2002 data.

[2] For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Umpqua River basin 303(d) listed streams, visit the Oregon Department of Environmental Quality's web page at http://www.deq.state.or.us/.

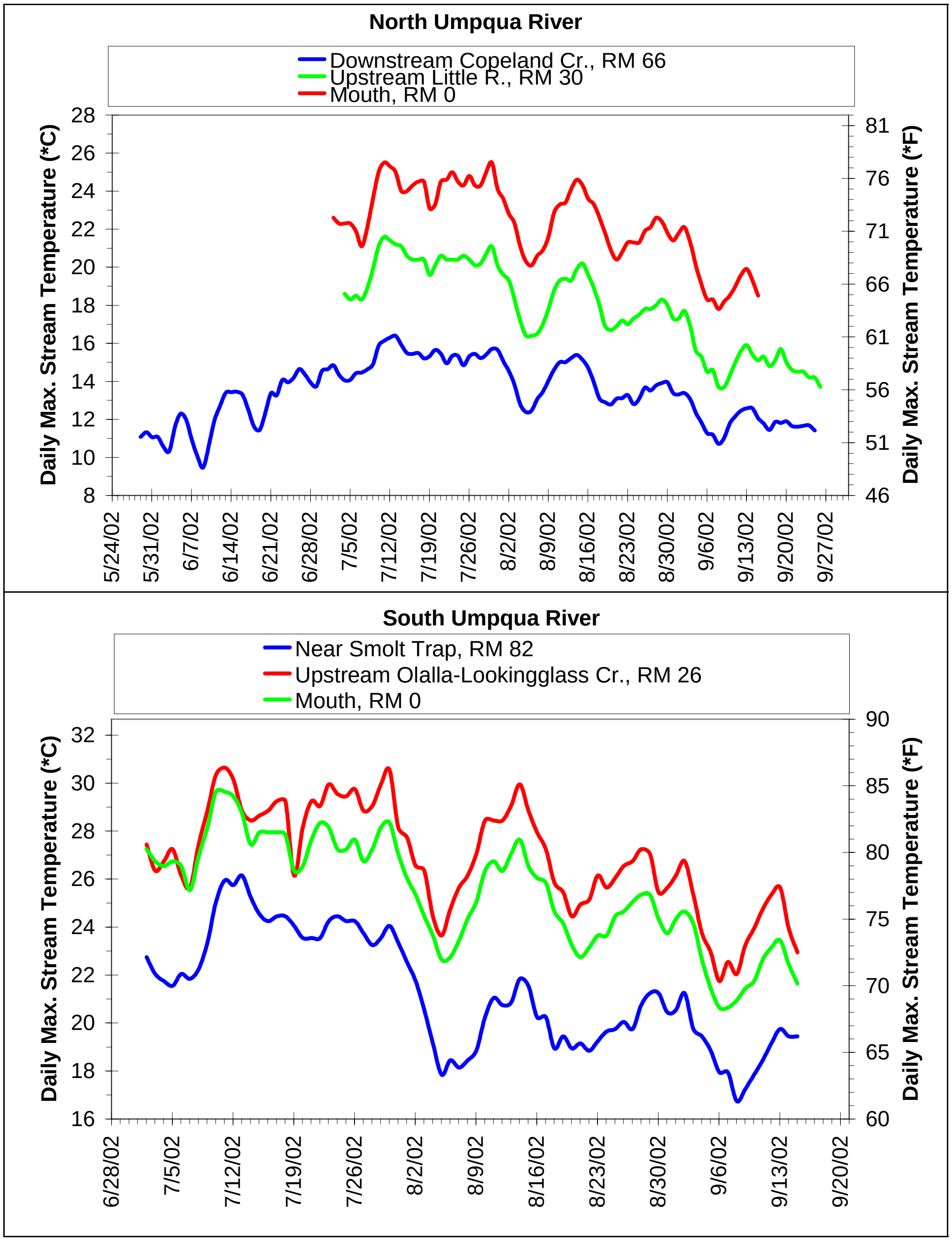

Figure 3.5 **Stream temperatures representing seasonal variation.**

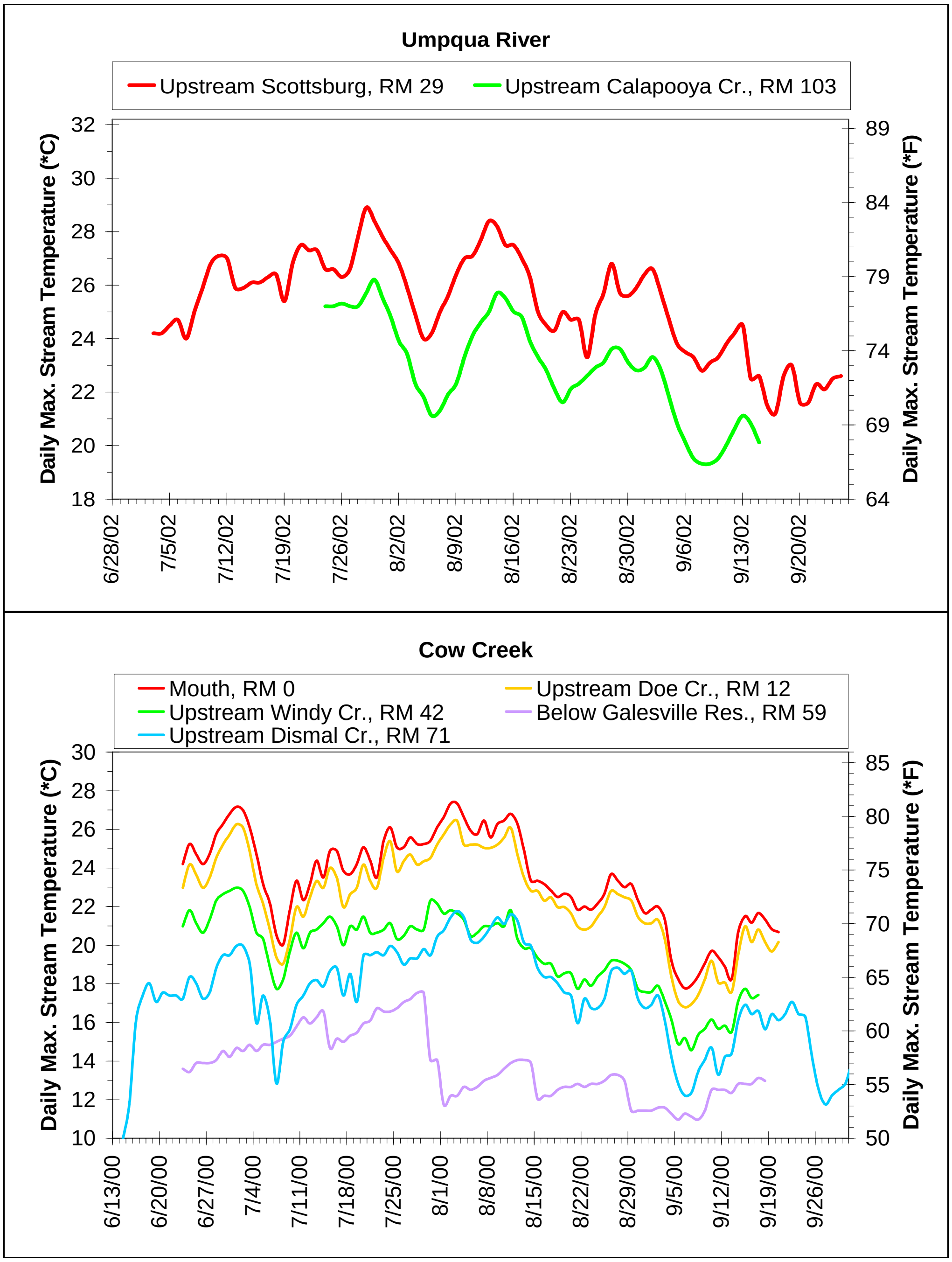

Figure 3.5 (continued). Stream temperatures representing seasonal variation.

3.2 EXISTING HEAT SOURCES AND EXCESS LOAD

This section presents the existing heat sources and excess load for all streams simulated. Excess load is the difference between the current pollutant load and the loading capacity of a water body. See **Section 3.5** for the actual nonpoint source TMDL load allocations and **Section 3.6** for point source waste load allocations. See **Section 3.7** for discussion of simulation methodology.

Excess heat load was calculated for both nonpoint and point sources. Of the total heat loading that occurs in the simulated streams during the summertime critical condition, 95% is attributed to natural background and 5% is from anthropogenic nonpoint sources (Figure 3.6).

Point sources contribute very little (<1%) of the total heat loading in the Umpqua River Basin, therefore, the point source contribution is not shown in the following figures.

For nonpoint sources, total daily solar heat load is the product of the daily solar heat flux and wetted surface area. The nonpoint source excess load is the difference between the current total daily solar heat load and the background total daily solar heat load.

Figure 3.7 on the following page, shows the solar heat load distributions separately for large and small stream reaches. Larger (wider) streams are difficult to shade, and hence have larger background solar loads. Smaller (narrower) streams are easier to shade and are more sensitive to riparian disturbances.

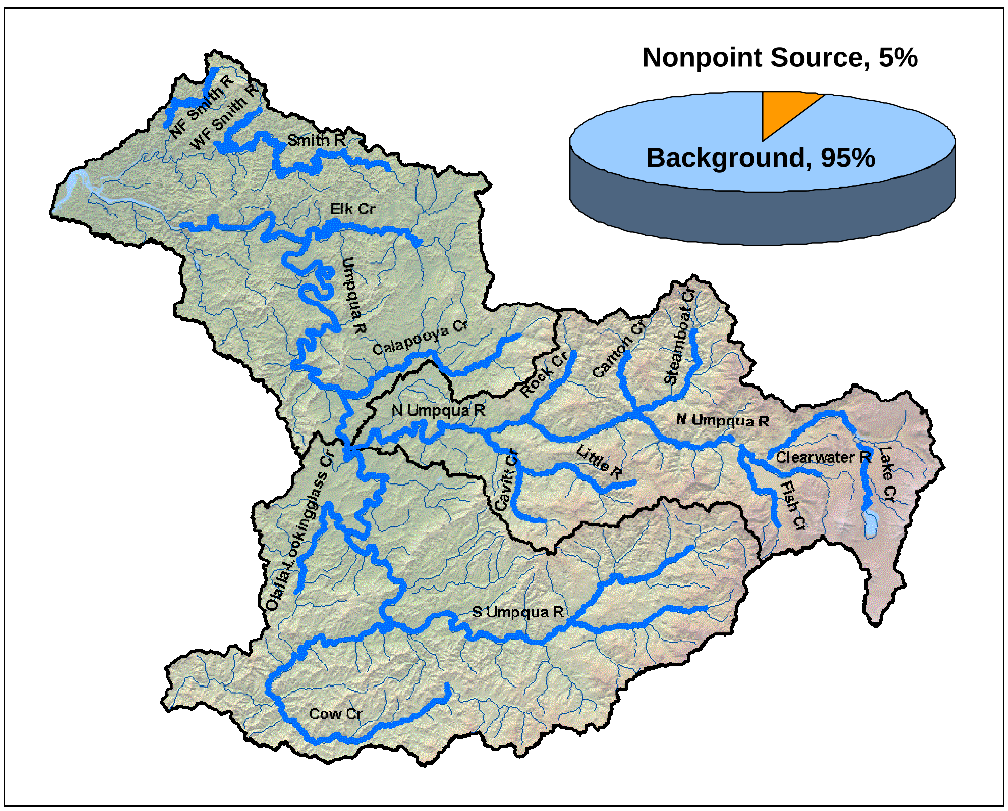

Figure 3.6 **Solar Heat Loading Distribution – All Modeled Streams**

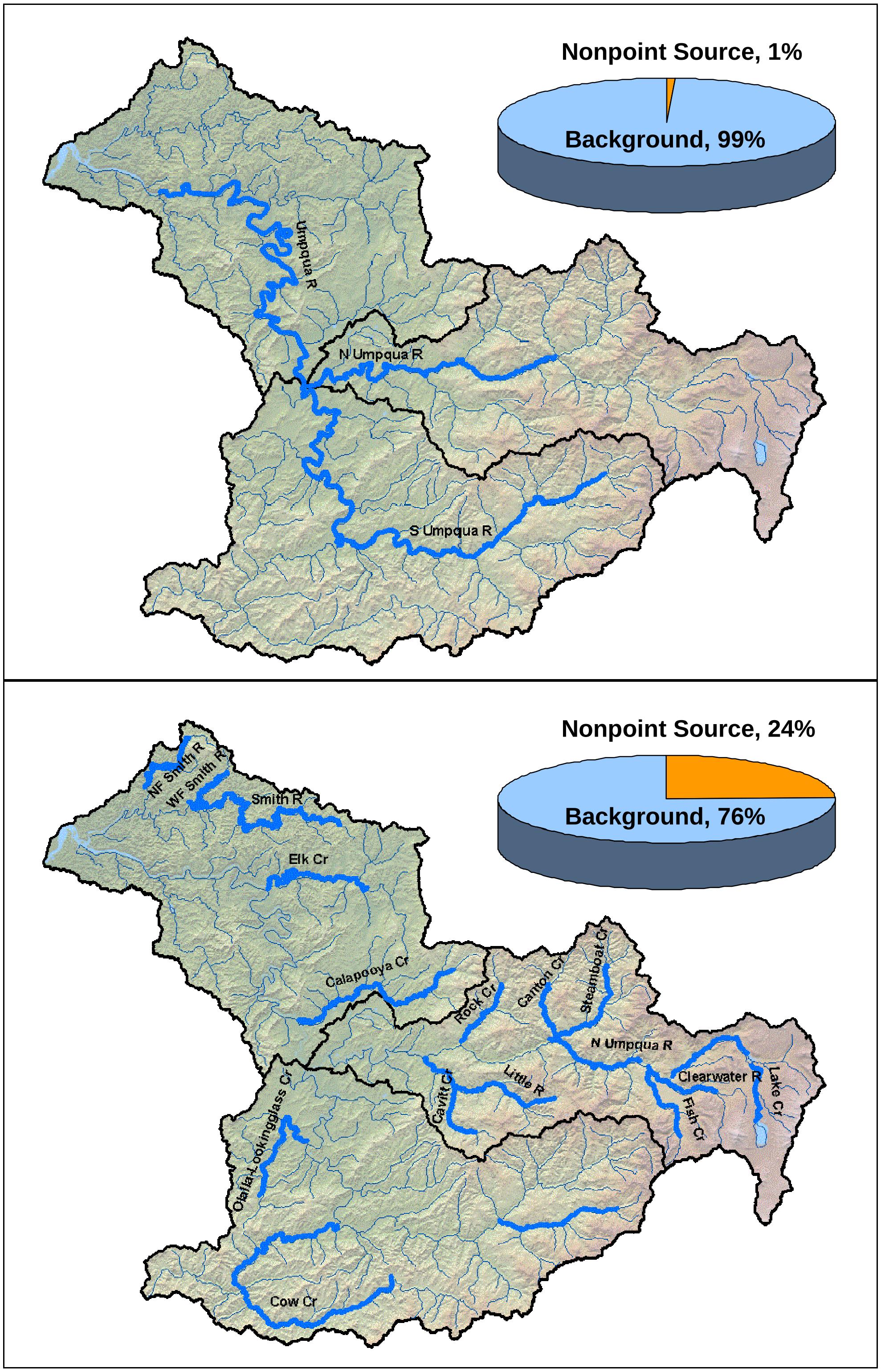

Figure 3.7 **Solar Heat Loading Distribution – Larger Streams (top) and Smaller Streams (bottom)**

3.2.1 Nonpoint Source Solar Heat

Nonpoint sources increase solar heat loading which in turn elevates stream temperatures. Near stream vegetation disturbance/removal reduces effective shade and exposes streams to higher levels of solar radiation. The heat load analysis is discussed in detail within **Umpqua River Basin Temperature TMDL Appendix**.

Riparian vegetation, stream morphology, hydrology, 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 human activities.

Historically, human activities have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the basin. The basin includes urban, agricultural, and forested lands. Additionally, hydroelectric projects and multiple points of diversion in the Umpqua River Basin have altered stream flow levels.

Low summertime flows decrease the thermal assimilative capacity of streams. Pollutant (solar radiation) loading causes larger temperature increases in stream segments where flows are reduced by human uses.

Figure 3.8 shows the longitudinal profiles of the current total heat flux and the background heat flux for the simulated streams. The values represent a typical day during the summertime critical period.

Larger streams, such as the South Umpqua and North Umpqua Rivers naturally experience a large solar flux because their channels are too wide to be significantly shaded by riparian vegetation. Smaller tributaries, such as Little River, are easier to shade and have smaller background solar flux values. Additionally, effective shade levels on smaller streams are more sensitive to riparian disturbances and so the differences between current condition solar flux and background solar flux can be larger.

Recall that this section is a source assessment for nonpoint sources. Figure 3.8 shows the heat flux for each stream that was simulated as part of the basin-scale stream network analysis. Refer to **Section 3.5** for the actual nonpoint source load allocations.

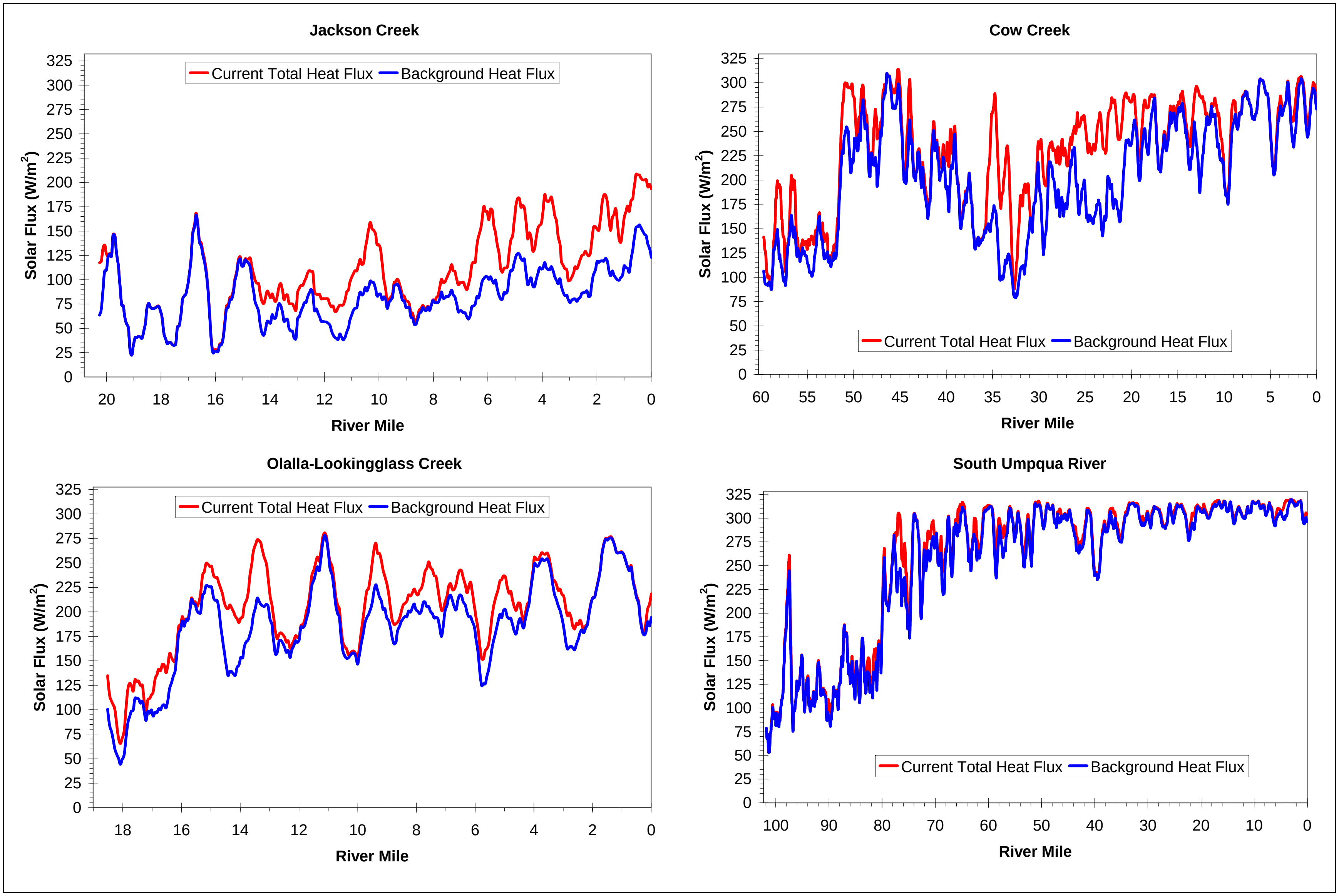

Figure 3.8 Current Total Heat Flux and Background Heat Flux

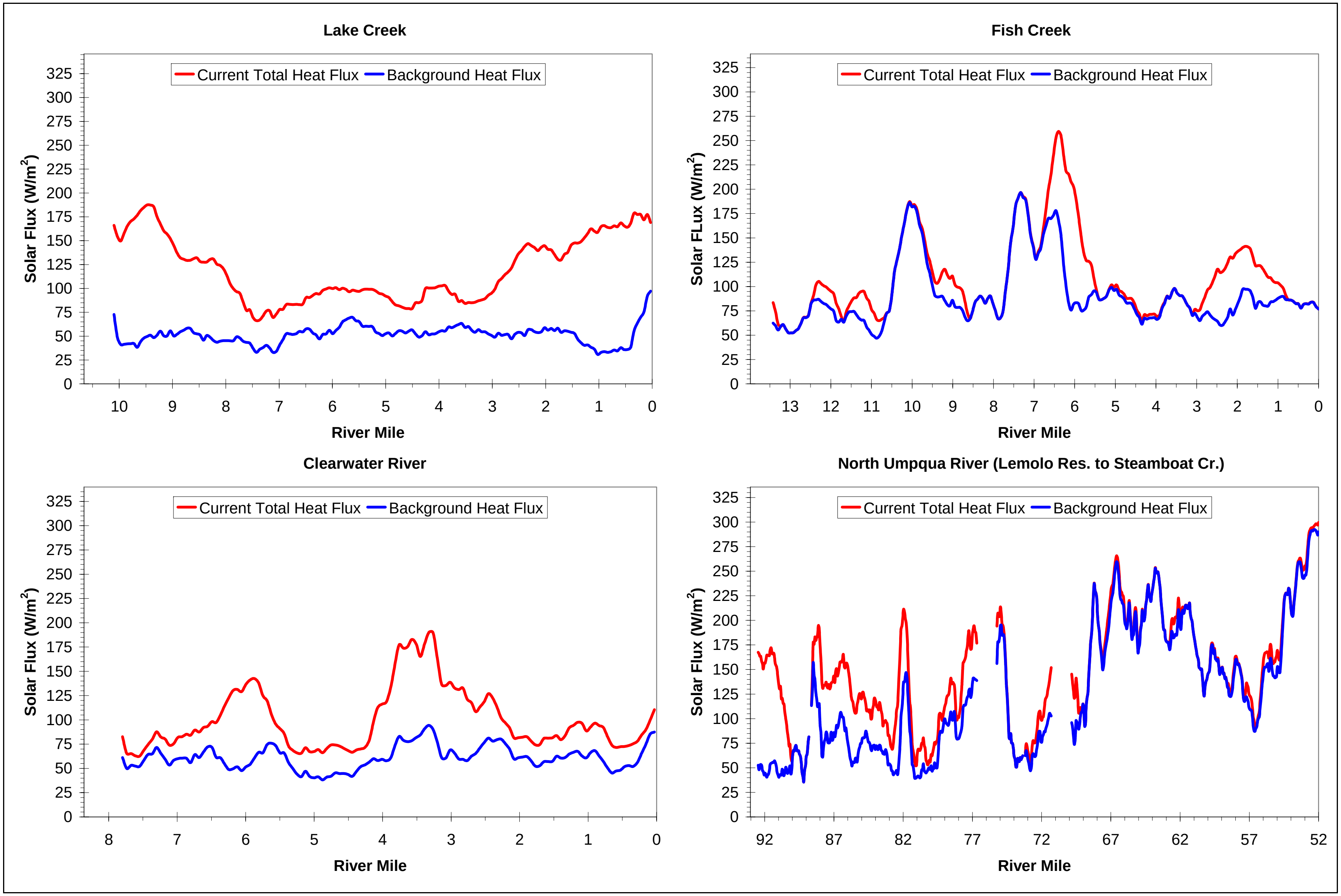

Figure 3.8 (Continued). Current Total Flux Load and Background Heat Flux

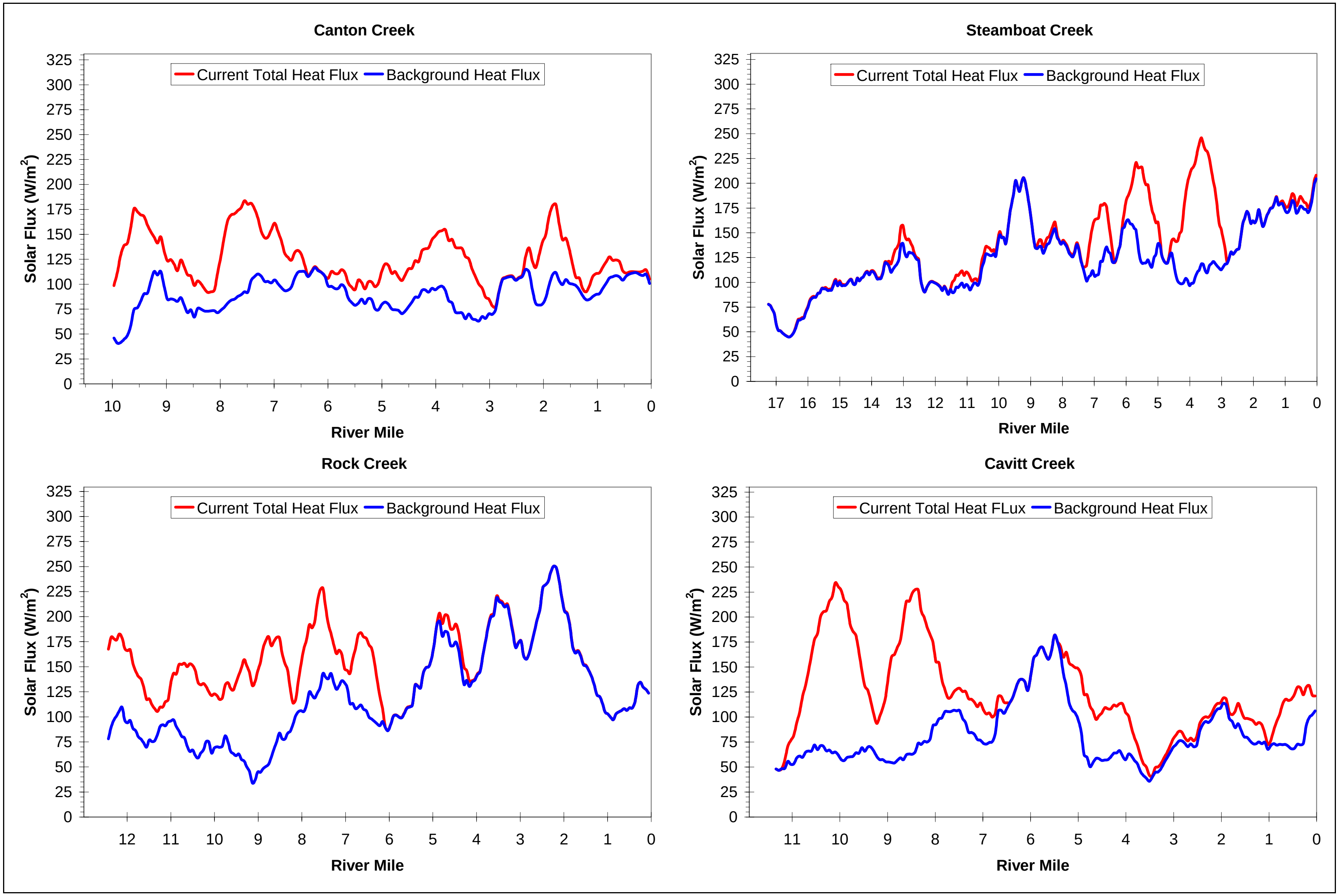

Figure 3.8 (Continued). Current Total Heat Flux and Background Heat Flux

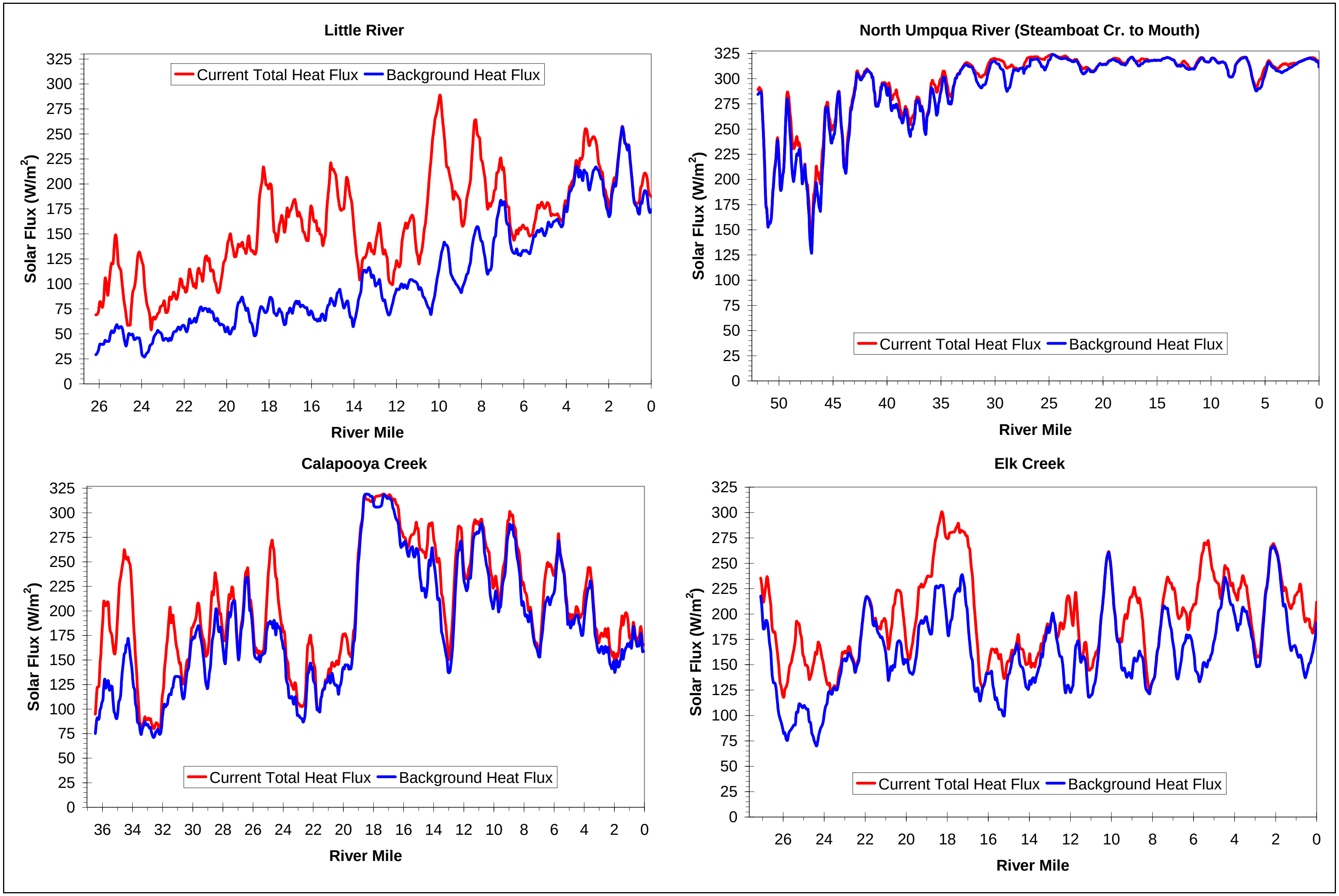

Figure 3.8 (Continued). Current Total Heat Flux and Background Heat Flux

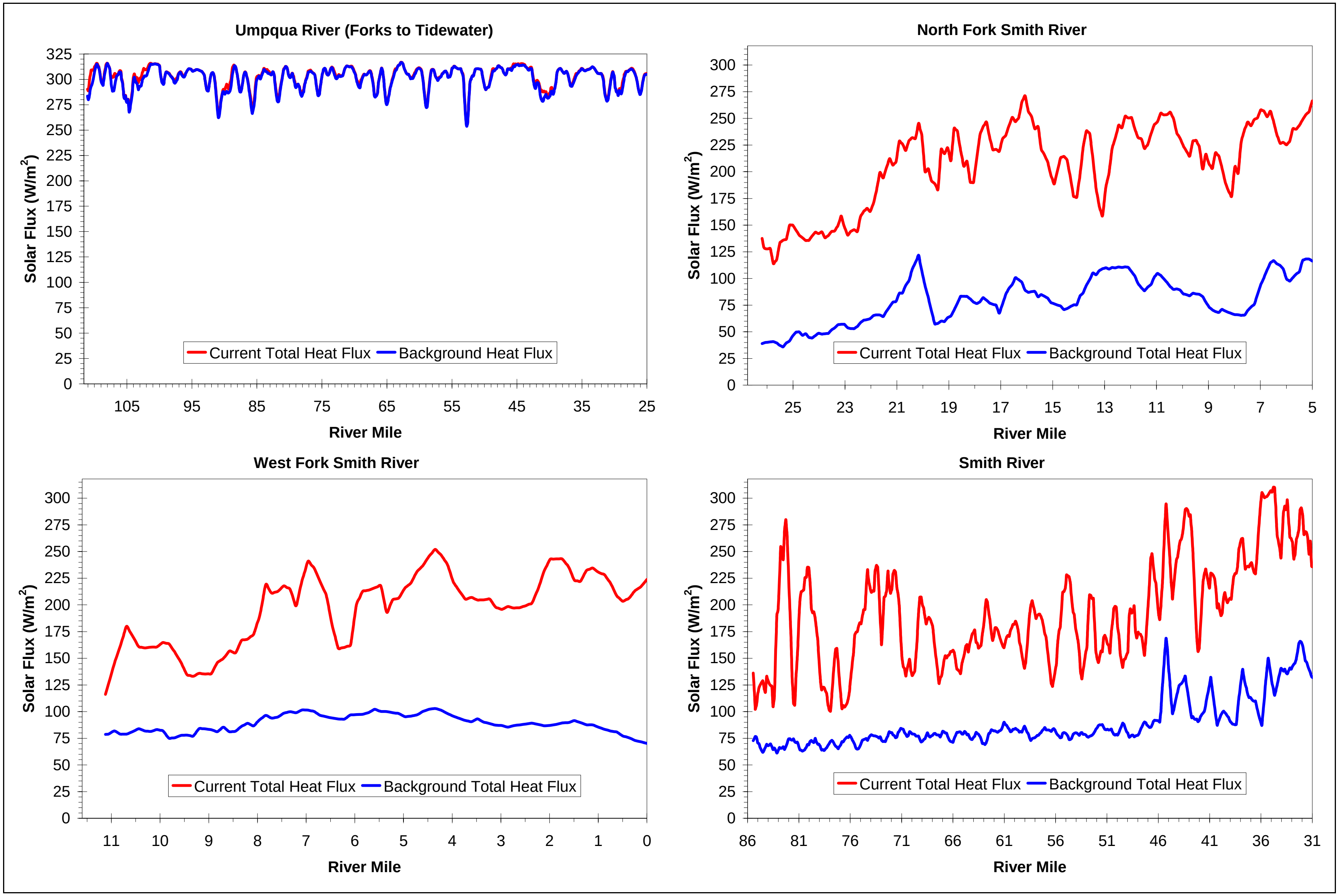

Figure 3.8 (Continued). Current Total Heat Flux and Background Heat Flux

Current total solar heat load was determined for each modeled stream by calculating the product of the solar flux and stream surface area (Table 3.5). The background solar heat load reflects conditions where the anthropogenic heat load is zero. Anthropogenic nonpoint source solar heat load is the difference between the current total solar heat load and the background solar heat load. The percent of total solar heat load from anthropogenic nonpoint sources is the anthropogenic solar head load divided by background solar head load.

Table 3.5 also shows the total loading according to stream size. The total solar heat loads for the large mainstems and the smaller tributaries are presented separately at the bottom of the table. 24% of the solar heat load on smaller streams is anthropogenic, compared to only 1% on the large streams. This difference is due to the fact that small streams have effective shade levels that are more sensitive to changes in riparian conditions. The system total is only 5% because large rivers such as the Umpqua and South Umpqua receive a large heat load this heavily weights the average.

Table 3.5 Solar Heat loads of simulated streams.

Stream	Current Total Solar Heat Load (Megawatts)	Background Solar Heat Load (Loading Capacity) (Megawatts)	Anthropogenic NPS Solar Heat Load (Excess Load) (Megawatts)	Portion of Current Total Solar Heat Load that is Anthropogenic NPS
Jackson Creek	36	26	10	28%
Cow Creek	443	366	77	17%
Olalla-Lookingglass Creek	112	99	13	12%
South Umpqua River	2,012	1,986	26	1%
Lake Creek	12	6	6	50%
Clearwater Creek	15	10	5	33%
Fish Creek	33	28	5	15%
North Umpqua R. (Lemolo Res. to Steamboat Cr.)	260	239	21	8%
Canton Creek	27	20	7	26%
Steamboat Creek	62	56	6	10%
Rock Creek	34	28	6	18%
Cavitt Creek	15	10	5	33%
Little River	93	67	26	28%
North Umpqua River (Steamboat Cr. to Mouth)	1,753	1,733	20	1%
Calapooya Creek	150	140	10	7%
Elk Creek	200	169	31	16%
Umpqua River (Forks to Tidewater)	4,476	4,455	21	0.5%
North Fork Smith River (Kentucky Cr. to RM 5.2)	146	59	87	60%
West Fork Smith River (RM 11.5 to Mouth)	45	20	25	55%
Smith River (Peterson Cr. to Johnson Cr.)	252	119	133	53%
SYSTEM TOTALS:	**10,174**	**9,635**	**539**	**5%**
Umpqua River, South Umpqua River, and Lower North Umpqua River Only	8,241	8,174	67	1%
Other Simulated Streams	1,933	1,461	471	24%

Figure 3.9 summarizes the simulated solar heat loads presented in Table 3.5. The larger rivers are shown in a separate graph because their heat loads are an order of magnitude greater than their smaller tributaries.

Generally, anthropogenic nonpoint sources make up a small portion of the current solar heat load received by streams in the Umpqua River basin. Much of the current solar heat load is attributed to natural or background sources.

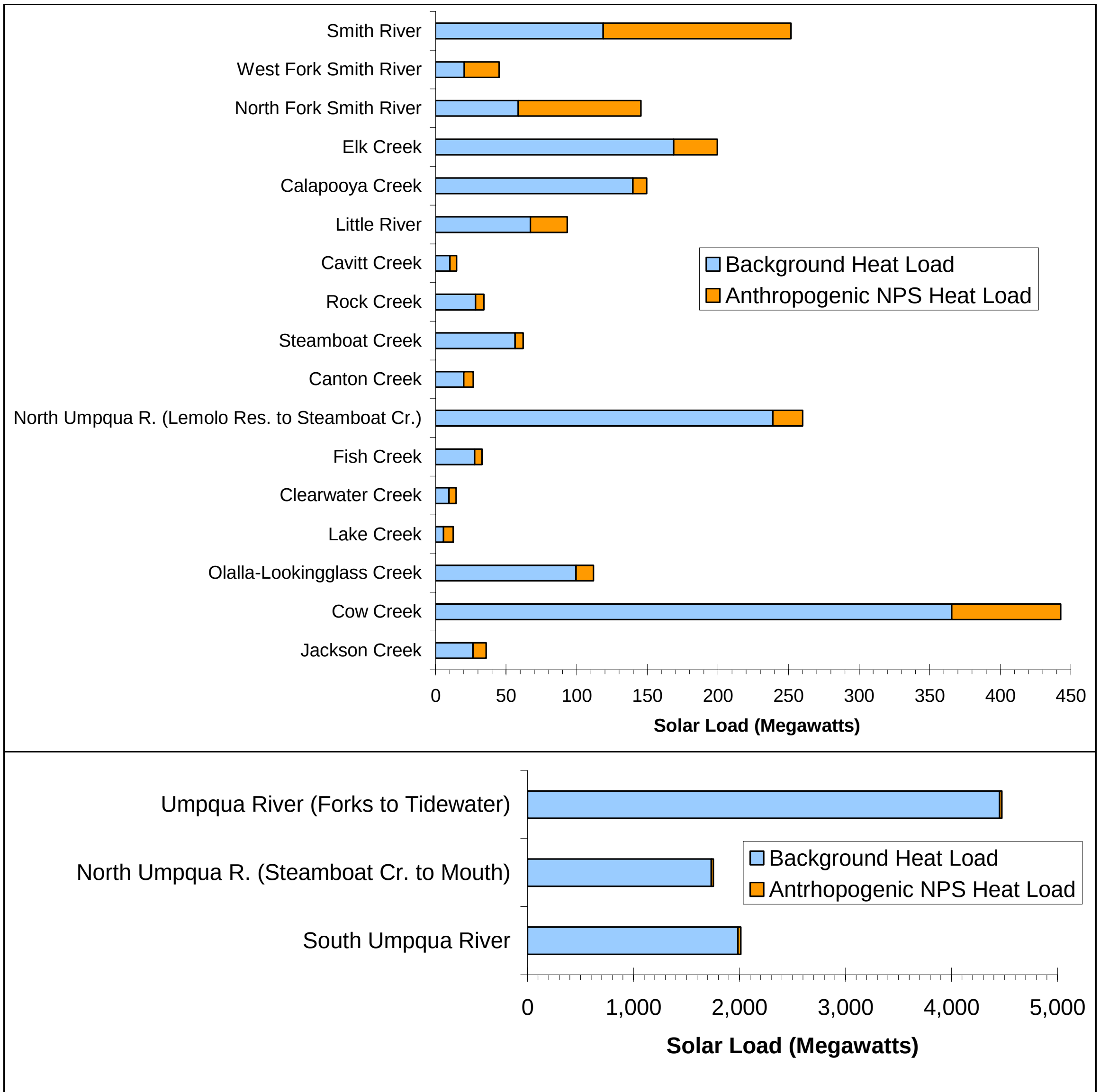

Figure 3.9 **Nonpoint Source (Anthropogenic) and Background Solar Heat Loads**

North Umpqua Hydro Electric Project

PacifiCorp's hydro electric project on the North Umpqua River is responsible for elevated stream temperatures between Lemolo Reservoir and the Umpqua River tidewater boundary. Several large diversions reduce flow volumes within the bypass reaches (the natural stream channel below the diversions). Small flow volumes are much more sensitive to solar heating and stream temperatures warm rapidly within the bypass reaches. Figure 3.10 shows the hydro electric project dam and bypass reach locations. Letters A through E refer to modeling reaches presented in figure 3.17.

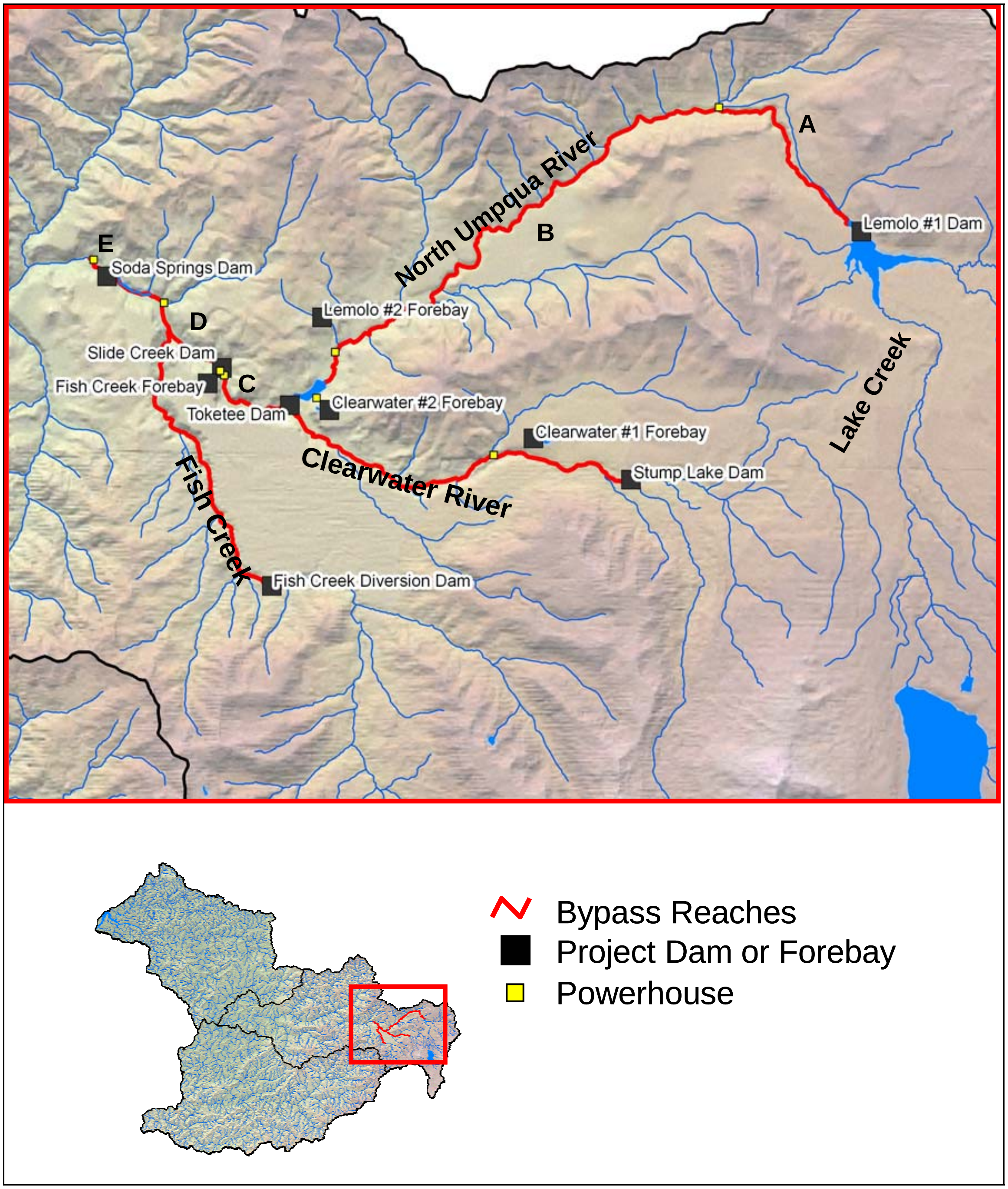

Figure 3.10 **North Umpqua Hydro Electric Project Area.**

Stream temperature simulations were performed from Lemolo Reservoir to the Umpqua River tidewater boundary. Potential vegetation (effective shade) and natural stream flows were simulated together and separately in order to determine the stream temperature impacts that each parameter has on the stream network. (See **Section 3.5.3** for the flow profiles between Lemolo Reservoir and Steamboat Creek.)

Figure 3.11 displays the temperature simulation results from Lemolo Reservoir all the way to the Umpqua River tidewater boundary. In the “Vegetation Only” scenario flow volumes were left at their current condition and effective shade was increased to its potential. In most reaches, the “Vegetation Only” results are identical to the current condition. In the “Flow Only” scenario, vegetation was left as its current condition and “natural” flows were used, assuming there were no dams, withdrawals, or diversions in the system. Natural flows resulted in cooler stream temperatures throughout the system. The “Natural Thermal Potential” scenario combines potential vegetation and natural flows.

Figure 3.11 shows that stream temperatures improved very little when potential effective shade was applied and current flows were used. Stream temperatures improved greatly when “natural” flows were applied and effective shade remained at the current condition.

Temperature simulations reveal that the hydro project flow reductions are the primary cause of elevated stream temperatures from Lemolo Reservoir to the Umpqua River tidewater boundary. For more detailed simulation information, refer to the **Umpqua River Basin Temperature TMDL Appendix**.

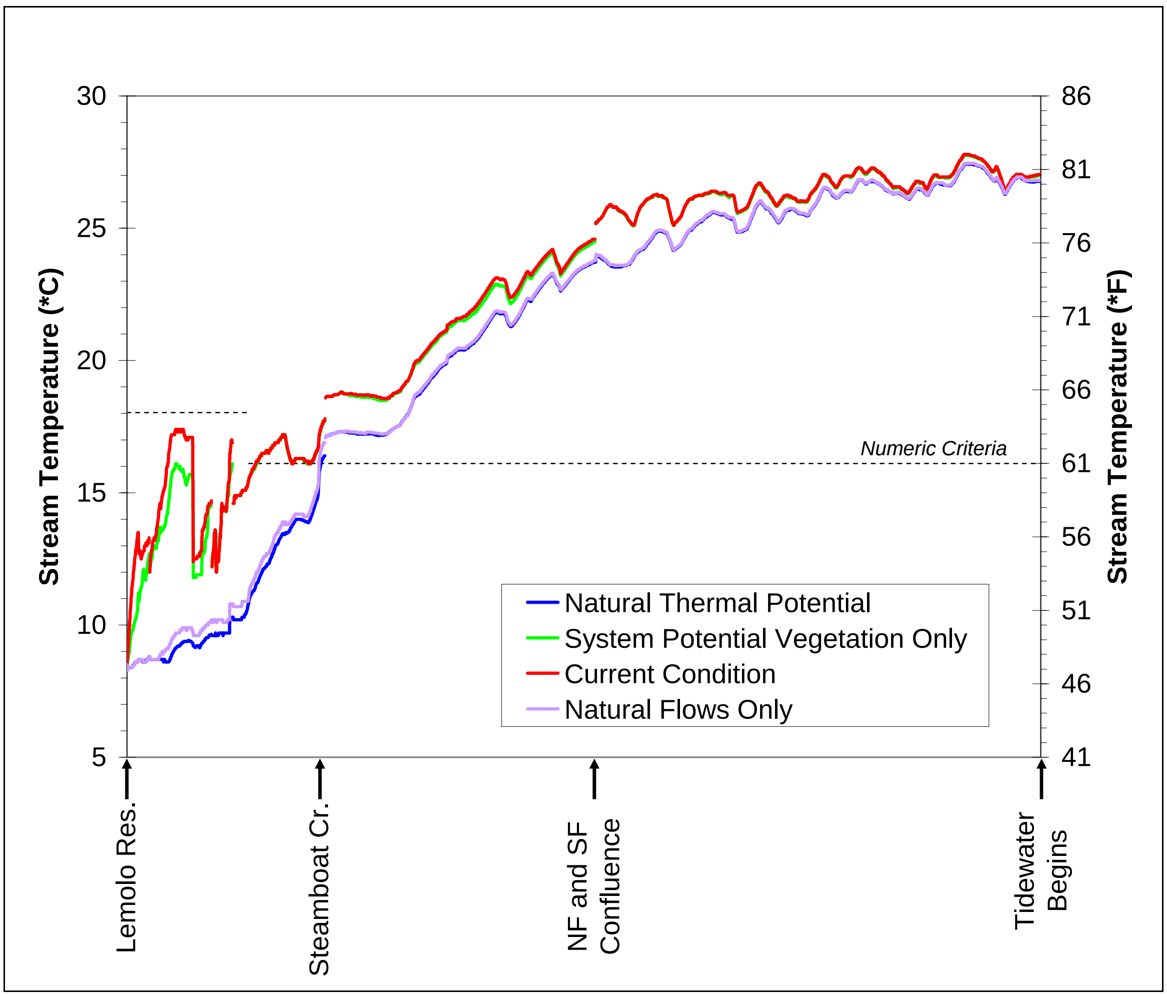

Figure 3.11 **Temperature Simulation Results by Scenario.**

3.3 LOADING CAPACITY

The water quality standard mandates a **loading capacity** based on the condition where stream temperatures do not increase more than 0.3^{o}C (human use allowance) above the applicable criteria at that point(s) of maximum impact**.**

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. EPA's current regulation defines loading capacity as "*the greatest amount of loading that a waterbody can receive without violating water quality standards*." (40 CFR § 130.2(f)).

The pollutants are anthropogenic increases in solar radiation loading (nonpoint sources) and heat loading from warm water discharge (point sources).

Summer **Loading capacities** in the Umpqua River Basin are the sum of (1) background solar radiation heat loading profiles (expressed as megawatts) based on potential vegetation characteristics that include natural disturbance and (2) allowable heat loads for NPDES permitted point sources.

The loading capacity is the sum of background, allowable nonpoint source heat, allowable point source heat, heat included in a margin of safety, and heat held as a reserve capacity.

TMDL = Loading Capacity = $H_B + H_{NPS\ LA} + H_{WLA} + H_{MOS} + H_{RC}$

Background (H_B) →	9,548 MW (simulated streams)[3]
Nonpoint Source Load Allocations ($H_{NPS\ LA}$) →	See Section 3.4 and Section 3.5
Waste Load Allocations (H_{WLA}) →	See Section 3.6
Margin of Safety (H_{MOS}) →	Implicit
Reserve Capacity (H_{RC}) →	1/3 of Human Use Allowance (0.1^{o}C)

A number of reaches are identified as currently meeting the applicable temperature target. The assimilative capacity of these streams could be allocated if the conditions of cold water protection [OAR 340-041-0228(11)] and antidegradation (OAR 340-041-0004) are met and analysis shows that the temperature human use allowance is not exceeded in downstream reaches. This analysis for the North Umpqua Hydro Project is presented in this document. Additional analysis could be completed for other reaches in which the current condition does not exceed the applicable temperature target.

There is a different set of streams for which analysis shows that the natural thermal potential is less than numeric criteria. In all cases, though, these streams eventually flow into reaches in which the natural thermal potential is greater than the numeric criteria. The TMDL presumes that the colder upstream water is needed in order to meet the natural thermal potential downstream. Once these streams achieve temperatures colder than the numeric criteria, additional analysis could be completed as described in the previous paragraph.

[3] Background is calculated only from the simulated 303(d) listed streams (Table 3.1). Little River, Cavitt Creek, and Clearwater River were simulated but are not assigned allocations in this TMDL. Refer to The Little River Watershed TMDL (ODEQ, 2001, approved by EPA 2002) for Little River watershed load allocations. Clearwater River is not on the 303(d) list for temperature.

3.4 ALLOCATIONS - SUMMARY

Load Allocations (Nonpoint Sources) - Load Allocations are portions of the loading capacity reserved for natural, human and future nonpoint pollutant sources.
Wasteload Allocations (Point Sources) - A Waste Load Allocation (WLA) is the amount of pollutant that a point source can contribute to the stream without violating water quality criteria.

Table 3.6 Load Allocation Summary

Background Load Allocation[4]	9,548 MW (total from simulated streams)
Anthropogenic Nonpoint Source Load Allocation	Equivalent to 1/3 of the Human Use Allowance (0.1°C) plus Assimilative Capacity where Available[5] - **Section 3.7**
North Umpqua Hydro Project Load Allocation (Nonpoint Source)	Equivalent to implementation of the 401 Certification minimum bypass reach flows during the non-spawning period.
Point Source Waste Load Allocation	Equivalent to 1/3 of the Human Use Allowance (0.1°C) plus Assimilative Capacity where Available. Refer to **Section 3.6**
Reserve Capacity	Equivalent to 1/3 of the Human Use Allowance (0.1°C).

The background load allocation is the total amount of heat that the simulated streams receive during the critical summertime period in the absence of anthropogenic influences. Natural disturbances to riparian vegetation are considered a background heat source and are incorporated in the background load allocation (see **Steam Temperature Appendix** for complete discussion). Natural disturbances are any non-human induced reductions of effective shade such as fire, flood, disease, storm, or insect damage. In most streams analyzed, the difference between current condition and natural thermal potential was greater than the variability predicted to be caused by natural disturbances. In 99.8% of the modeled reaches, the difference between predicted natural thermal potential with and without natural disturbance was less than the uncertainty of the calibrated models (0.5° Celsius).

The anthropogenic nonpoint source load allocation is the amount of heat equivalent to 1/3 of the human use allowance (cumulative 0.1°C increase at the point(s) of maximum impact). Due to the diffuse nature of nonpoint source pollution and seasonal variability, the nonpoint source load allocation associated with the human use allowance will vary longitudinally and temporally. (For example, the same amount of heat will have a larger temperature effect on a small stream than it will on a large stream, so allocations are location-dependent.) Therefore, a quantified nonpoint source load allocation is not feasible. Surrogate measures are used to translate nonpoint source load allocations (see **Section 3.5**).

Heat Source modeling was performed to demonstrate that the §401 Certification minimum bypass reach flows do not cause summer stream temperatures to exceed the applicable criteria within the hydroelectric project or anywhere downstream (see **Section 3.7**). The §401 Certification minimum bypass reach flows are much less than the natural flows, resulting in more rapid stream heating and higher temperatures than the natural thermal potential.

Point source waste load allocations for the non-spawning period and are dependent upon effluent flows and temperatures and stream flows and temperatures (see **Section 3.6**). The reserve capacity sets aside 1/3 of the human use allowance (0.1°C) for future sources.

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[4] Background is calculated only from the simulated 303(d) listed streams (Table 3.1). Little River, Cavitt Creek, and Clearwater River were simulated but are not assigned allocations in this TMDL. Refer to The Little River Watershed TMDL (ODEQ, 2001, approved by EPA 2002) for Little River watershed load allocations. Clearwater River is not on the 303(d) list for temperature.

[5] Assimilative Capacity may be translated into a heat load that is shared by point and nonpoint sources.

3.5 NONPOINT SOURCE LOAD ALLOCATIONS - SURROGATE MEASURES

The Umpqua River Basin Temperature TMDL incorporates measures other than "*daily loads*" to fulfill requirements of the Clean Water Act §303(d). Although a loading capacity for heat energy is derived (e.g. megawatts), it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat energy loads, this TMDL allocates "*other appropriate measures*" (or surrogate measures) as provided under EPA regulations (40 CFR 130.2(i)).

Effective shade is the surrogate measure that translates easily into solar heat load. It is simple to measure effective shade at the stream surface using a relatively inexpensive instrument called a Solar Pathfinder™.

The term 'shade' has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, *effective shade* is defined as the percent reduction of potential daily solar radiation load delivered to the water surface. The role of effective shade in this TMDL is to prevent or reduce heating by solar radiation and serve as a linear translator to the loading capacities.

This TMDL contains four types of nonpoint source load allocations:

1. Site-specific effective shade allocations apply to the streams that have been simulated (Section 3.5.1).

2. Effective shade curves are generalized allocations that apply to all other Umpqua River basin streams covered by this TMDL, but that have not been simulated (Section 3.5.2),

3. Site-specific channel width targets (Section 3.5.3).

4. North Umpqua hydro electric project reaches standard attainment is based on implementation of the 401 certification bypass reach minimum flows (Section 3.5.4).

Unless otherwise stated within **Section 3.7 (Temperature Simulation Results)**, the applicable nonpoint source load allocations for Umpqua River Basin streams are based upon potential effective shade values presented in this section. Analysis indicates that most streams simulated have no assimilative capacity. Therefore, nonpoint sources are allocated a portion of the human use allowance (0.1^{o}C cumulative increase at the point of maximum impact). When a stream has assimilative capacity, nonpoint and point sources may receive allocations greater than background.

3.5.1 Nonpoint Source Load Allocations - Site Specific Effective Shade

Site specific effective shade surrogates were developed to help translate the nonpoint source heat load allocations. Attainment of the effective shade surrogate measures is equivalent to attainment of the nonpoint source heat load allocations (see Section 3.7 for simulation results).

Figure 3.12 displays the 1-kilometer moving average effective shade values that correspond to the nonpoint source loading capacities of simulated 303(d) listed streams in the Umpqua River Basin. The "Current Condition" is the actual effective shade at the stream surface, including the effects of near stream vegetation and topography. The "Nonpoint Source (NPS) Loading Capacity" is the amount of effective shade at the stream surface under potential vegetation conditions. The "Natural Disturbance Range" indicates the shade levels that could potentially occur in the event of natural disturbances. The lower end of that range represents that amount of shade that the stream would receive if topography were the only shade-producing feature (i.e., no vegetation). **The Umpqua River Basin Temperature TMDL Appendix** contains detailed descriptions of the methodology used to develop the temperature TMDL.

The "NPS Loading Capacity" (blue line) represents the maximum possible effective shade for a given location, assuming the vegetation is fully mature. Caution should be used when interpreting the charts in Figure 3.12. This TMDL recognizes that is impossible for an entire stream to be at its maximum potential effective shade everywhere, all the time. In reality, natural disturbances will create a variety of tree heights and densities and effective shade levels in many reaches will be lower than the "NPS Loading Capacity", or somewhere within the "Natural Disturbance Range". Reductions in effective shade caused by natural disturbance are not considered a violation of the TMDL or water quality standards.

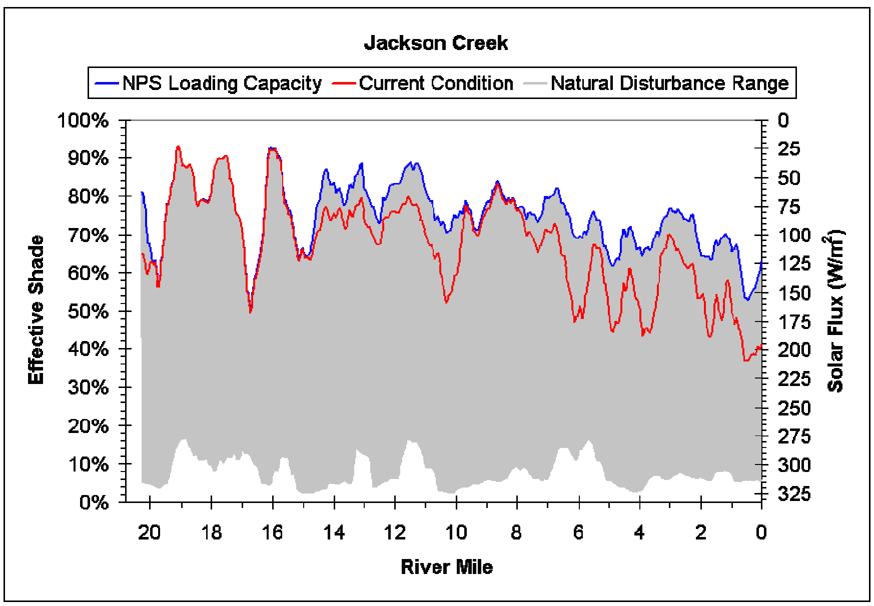


Figure 3.1 **Effective Shade and Solar Heat Load for simulated streams. The grey area is the range of natural disturbance that could potentially occur with the lowest end of the range representing topographic shade.**

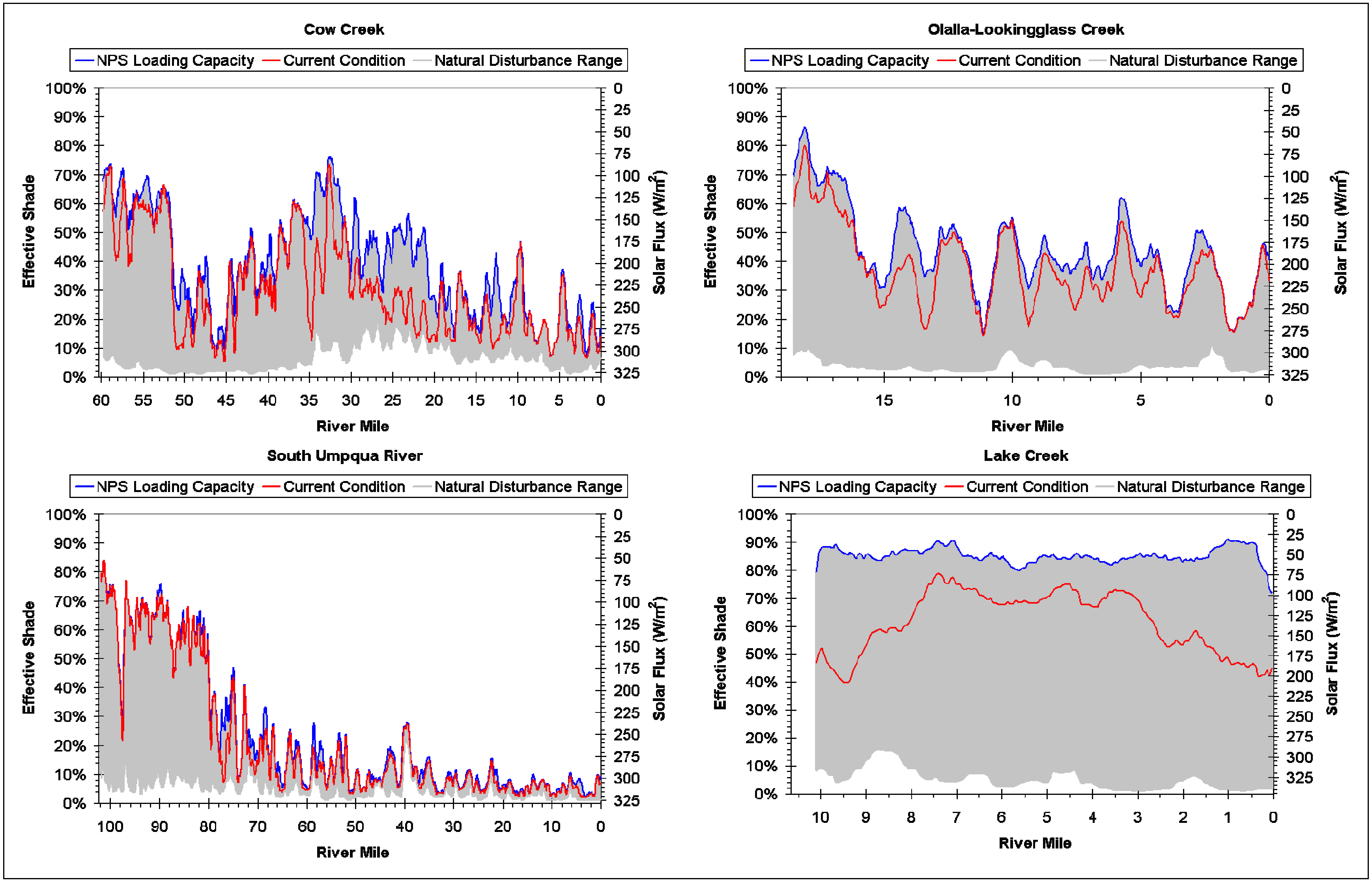


Figure 3.12 (continued) Effective Shade and Solar Heat Load for simulated streams. The grey area is the range of natural disturbance that could potentially occur with the lowest end of the range representing topographic shade.

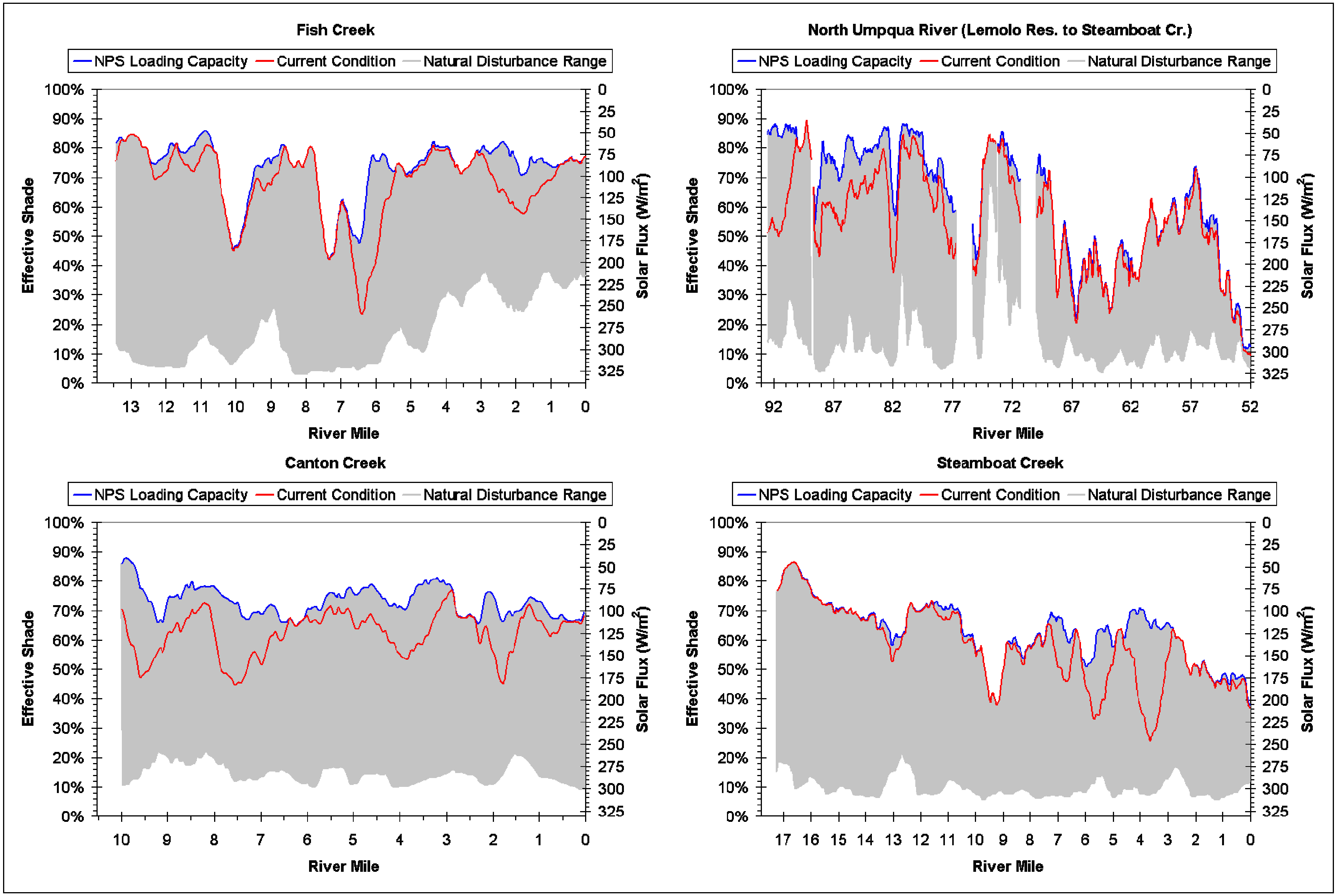


Figure 3.12 (continued). Effective Shade and Solar Heat Load for simulated streams. The grey area is the range of natural disturbance that could potentially occur with the lowest end of the range representing topographic shade.

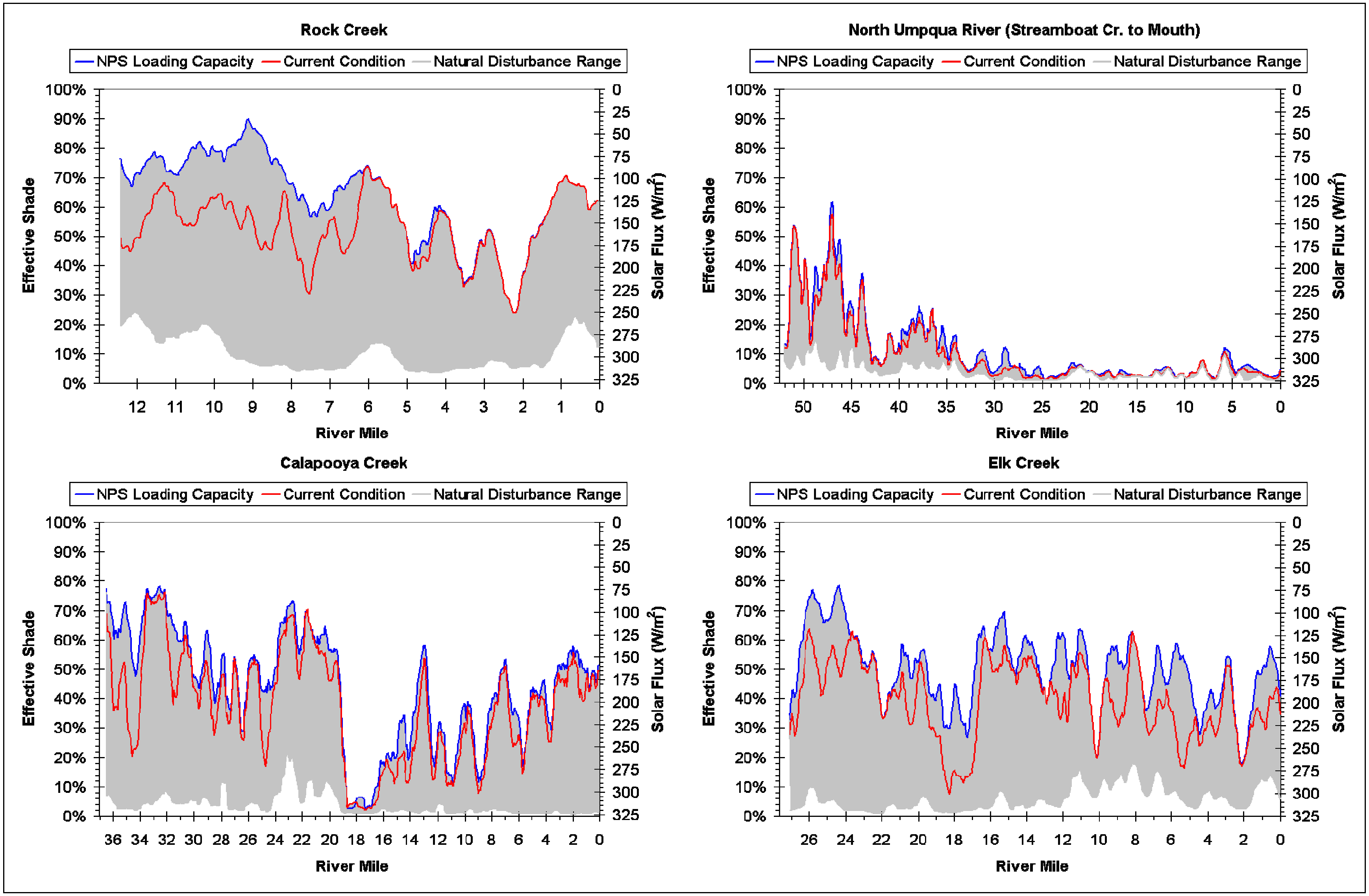


Figure 3.12 (continued). Effective Shade and Solar Heat Load for simulated streams. The grey area is the range of natural disturbance that could potentially occur with the lowest end of the range representing topographic shade.

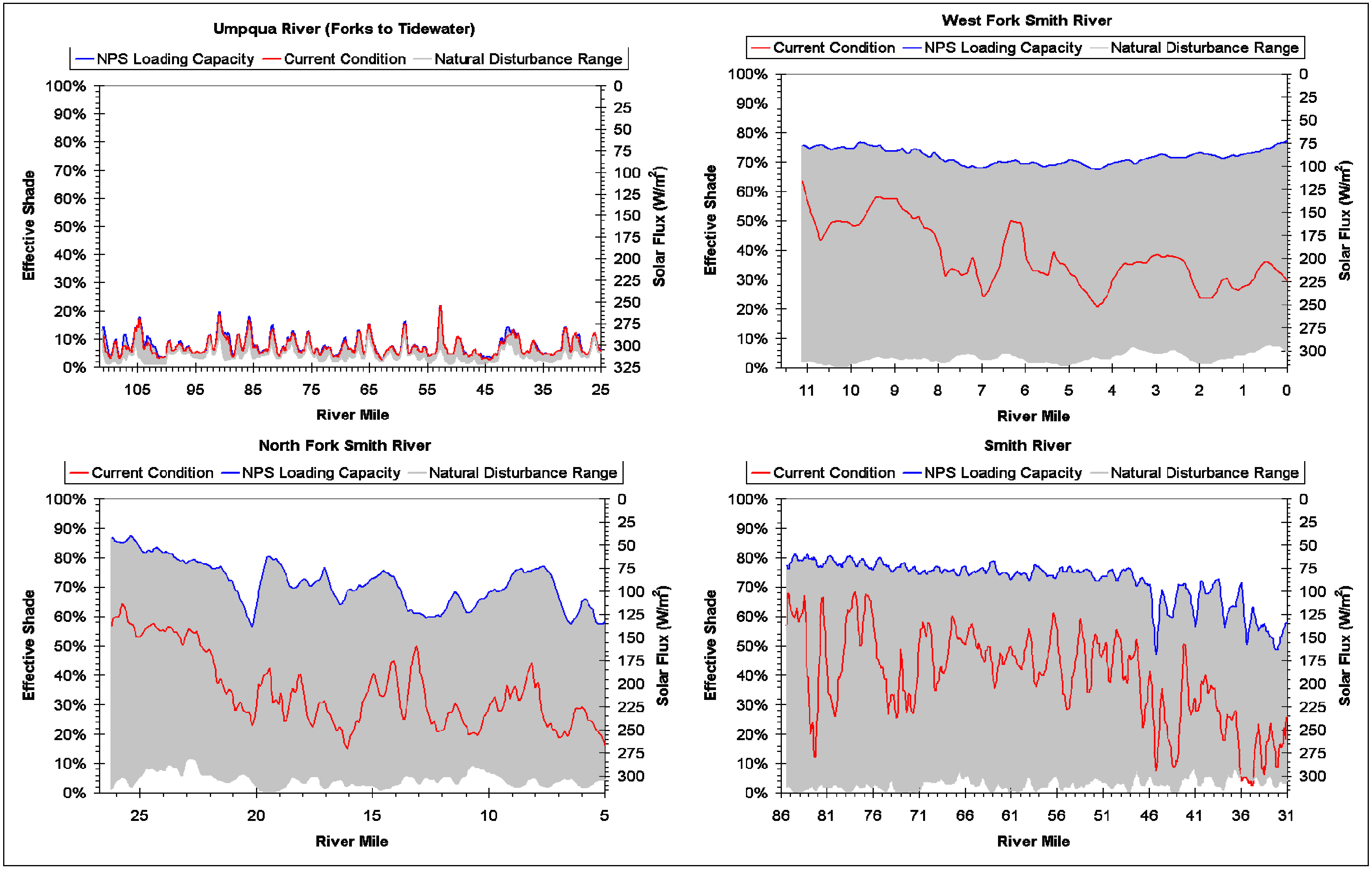


Figure 3.12 (continued). Effective Shade and Solar Heat Load for simulated streams. The grey area is the range of natural disturbance that could potentially occur with the lowest end of the range representing topographic shade.

3.5.2 Nonpoint Source Load Allocations - Effective Shade Curves

Effective shade curves are general heat load allocations applicable to any stream that was not specifically simulated for temperature. The heat load and effective shade surrogates are identified by region and channel width for different types of potential vegetation.

Effective shade curves represent the *maximum* possible effective shade for a given vegetation type. Natural disturbance was not included in the effective shade curve calculations. The values presented within the effective shade curves represent the effective shade that would be attained if the vegetation were at its stated potential height and density.

Local geology, geography, soils, climate, legacy impacts, natural disturbance rates, and other factors may prevent effective shade from reaching the values presented in the effective shade curves. The goal of the Umpqua River Basin Temperature TMDL is to minimize anthropogenic impacts on effect shade. Natural conditions or natural disturbances (non-anthropogenic) that result in effective shade below the maximum potential will not be considered out of compliance with the TMDL. This TMDL recognizes that unpredictable natural disturbances may result in effective shade well below the levels presented in the effective shade curves.

Smith River Watershed Effective Shade Curve

The Smith River watershed potential vegetation was determined in cooperation with the Smith River Watershed Council. Figure 3.13 shows the effective shade curve applicable to the Smith River Watershed.

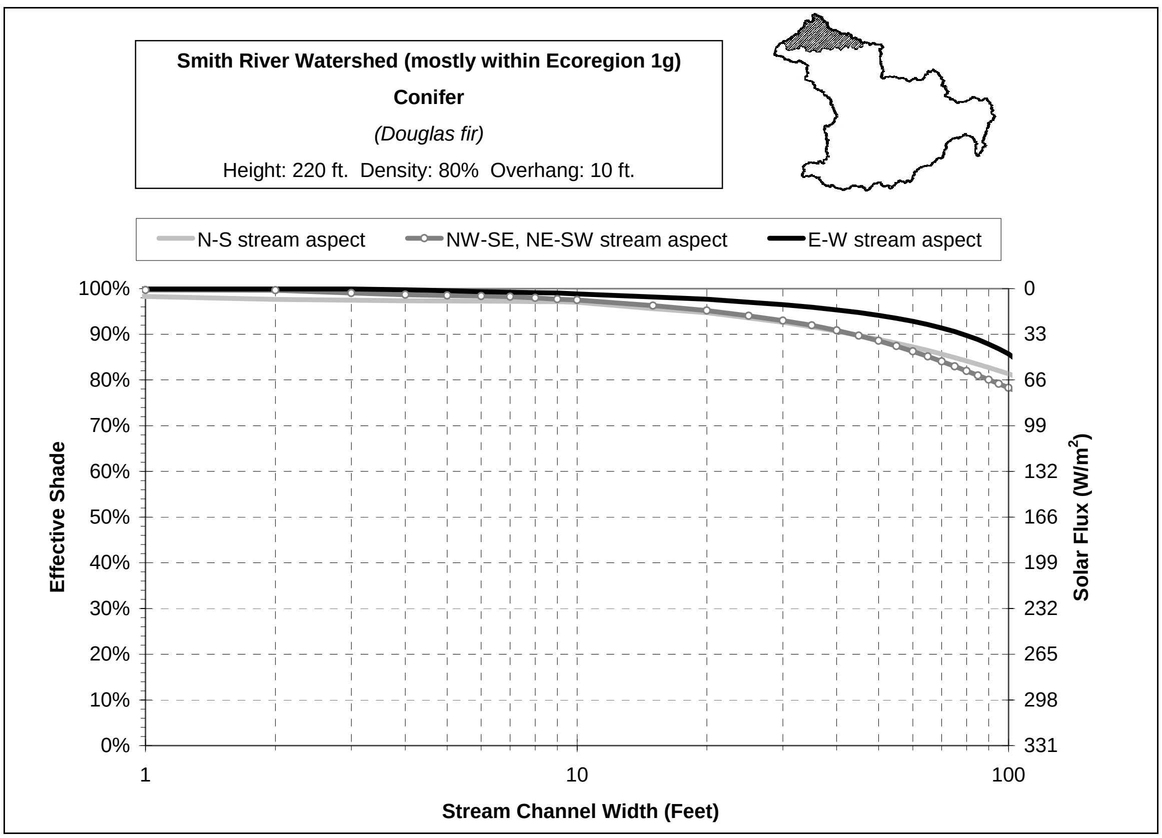


Figure 3.12 **Smith River Watershed Effective Shade Curve.**

Ecoregion-Based Effective Shade Curves

The Umpqua River Basin technical committee determined potential vegetation for each ecoregion in the basin.

Ecoregion-specific effective shade curves were derived for different vegetation types as a function of channel width and apply to all areas except the Smith River watershed. The effective shade curves account for latitude, critical summertime period (August 1), elevation and stream aspect. The potential vegetation types and the associated height, density and overhang were determined by the Umpqua River Basin TMDL technical committee which consisted of local experts (see **Umpqua River Basin Temperature TMDL Appendix**).

Site-specific effective shade simulations (i.e., Heat Source modeling) supercede the effective shade curves (see **Section 3.5.1**).

Figure 3.14 displays the locations of each EPA Level IV ecoregion. The ecoregion codes are defined within Figure 3.15, which contains the effective shade curves for each potential vegetation type and ecoregion.

Reminder: The allocations within this TMDL do not apply to the Little River watershed. See the Little River Watershed TMDL (ODEQ, 2001, approved by EPA in 2002) for those effective shade allocations.

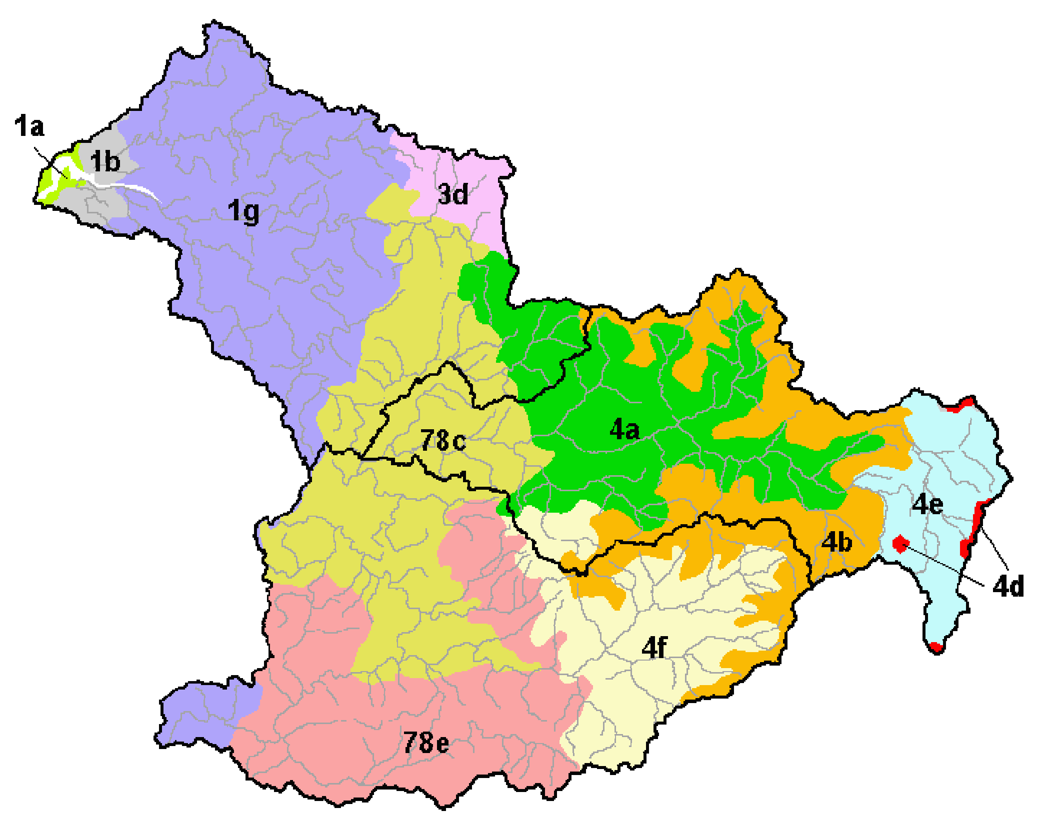
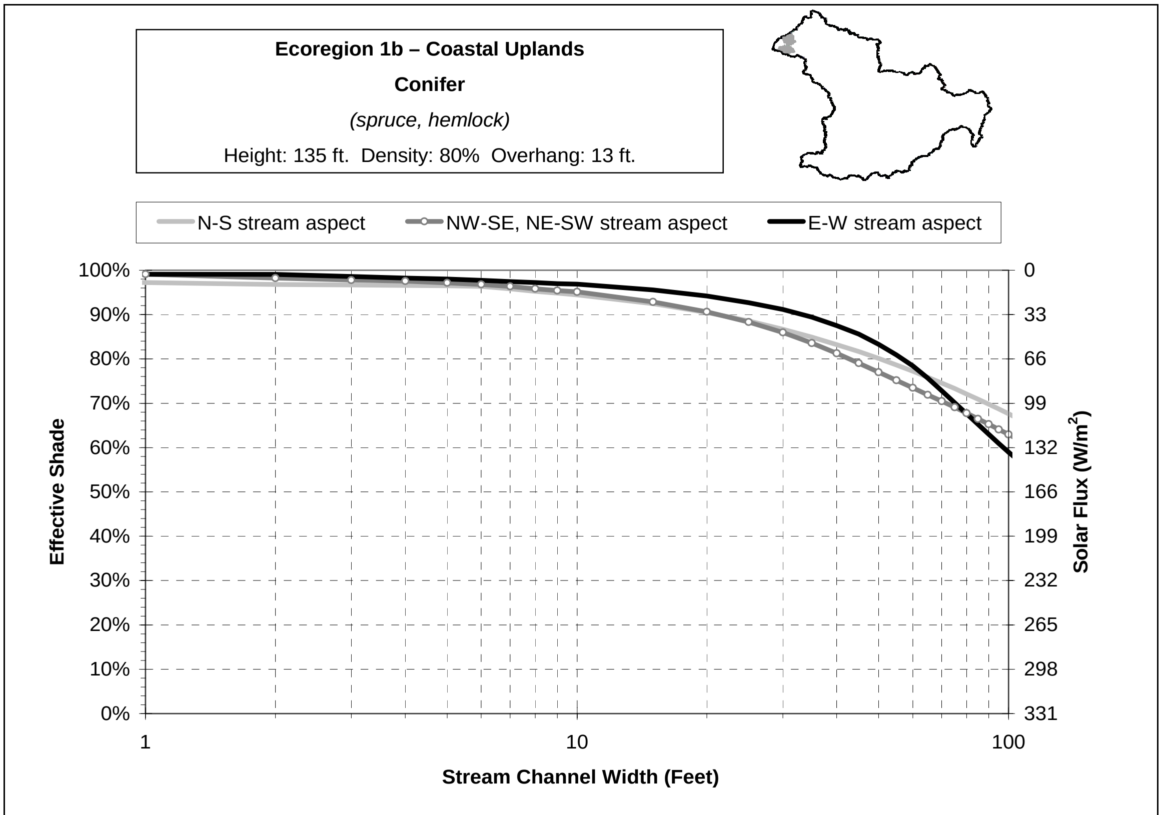


Figure 3.13 EPA Level IV Ecoregions used for the Effective Shade Curves



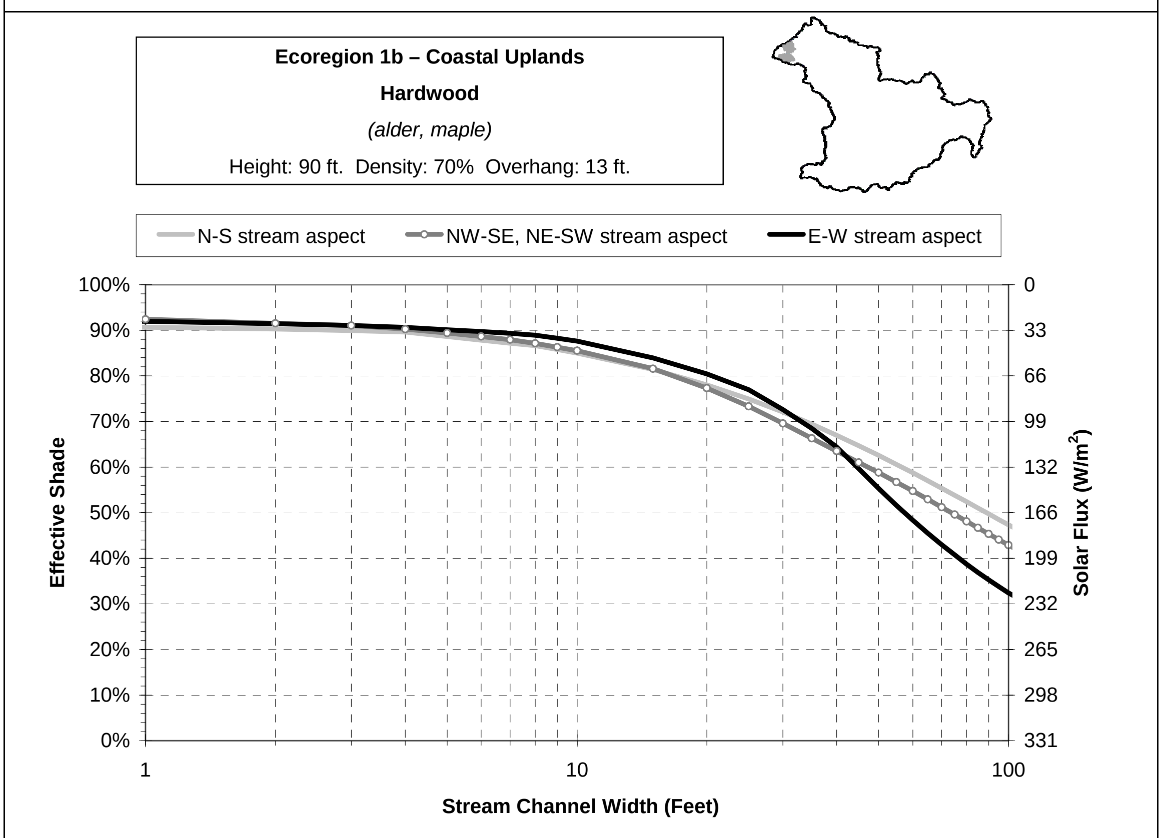
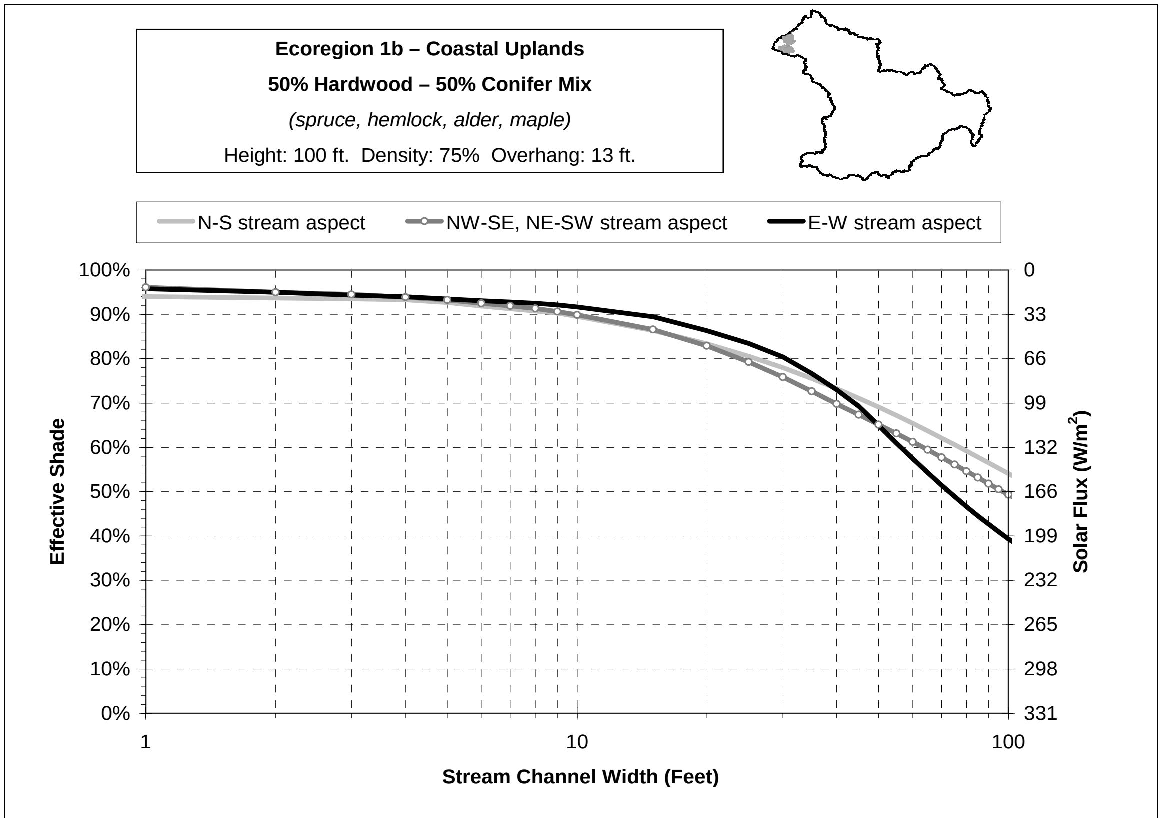


Figure 3.14 **Effective Shade Curves**



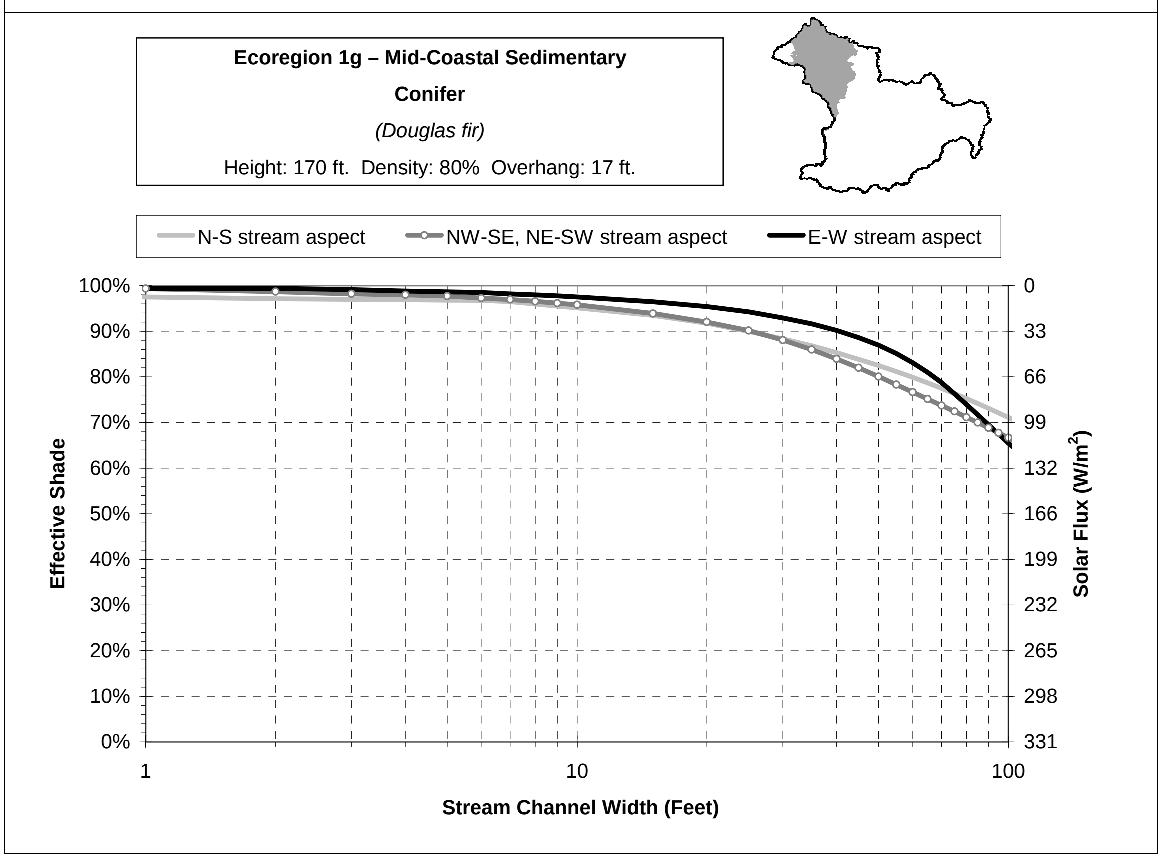
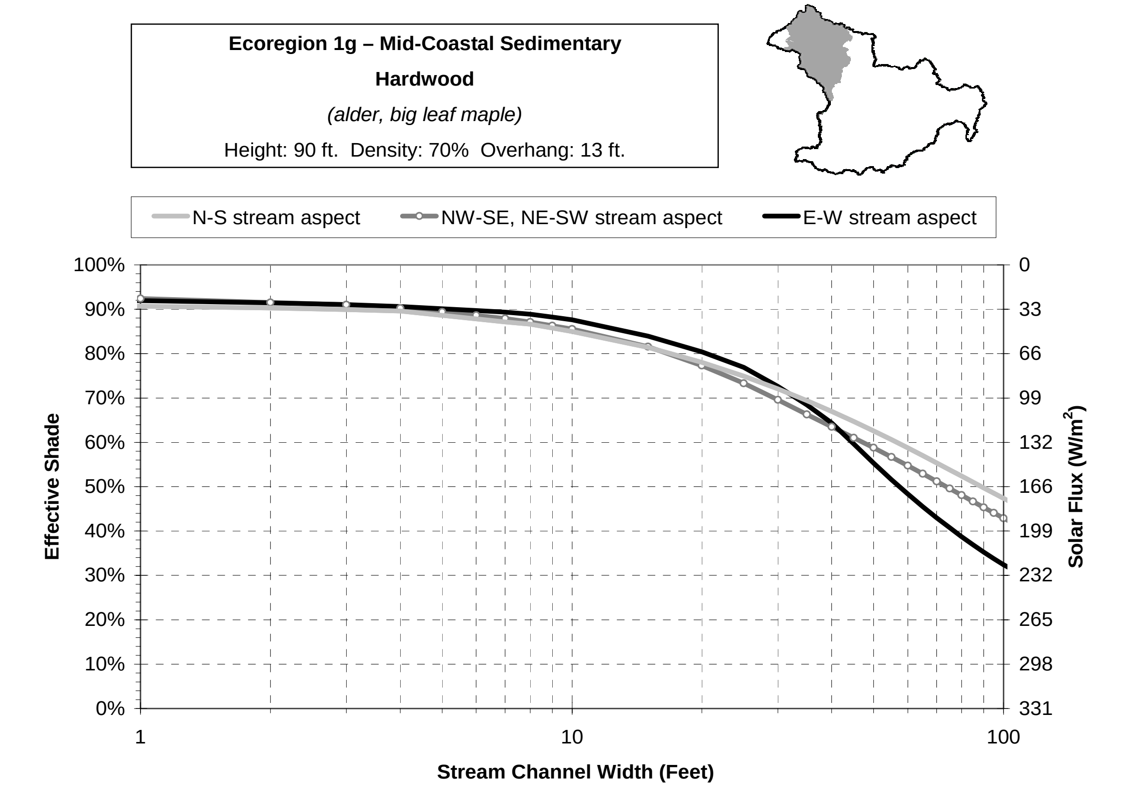


Figure 3.15 (continued). Effective Shade Curves



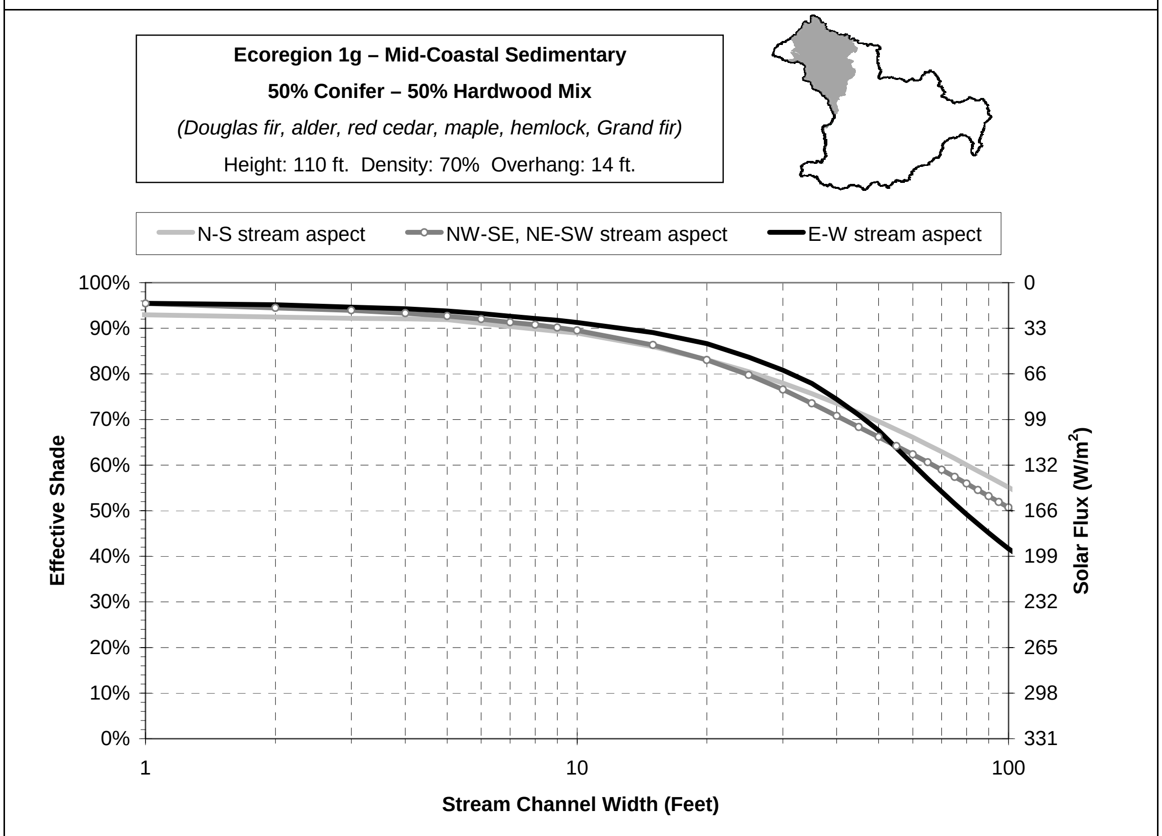
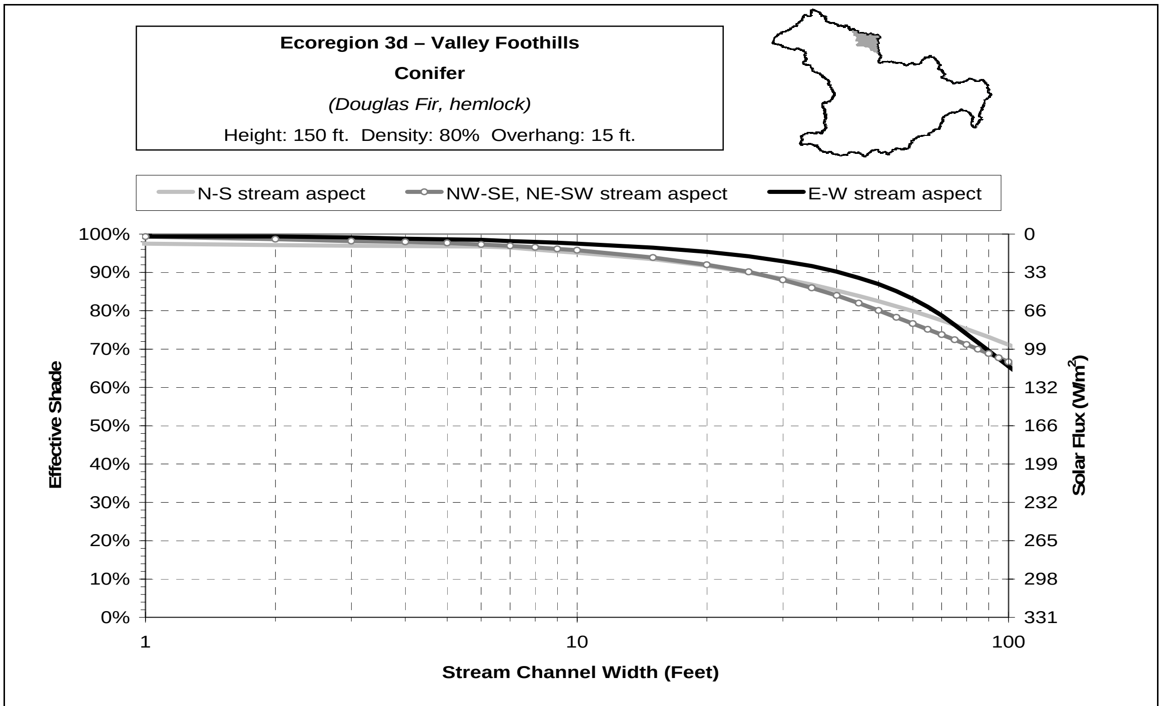


Figure 3.15 (continued). Effective Shade Curves



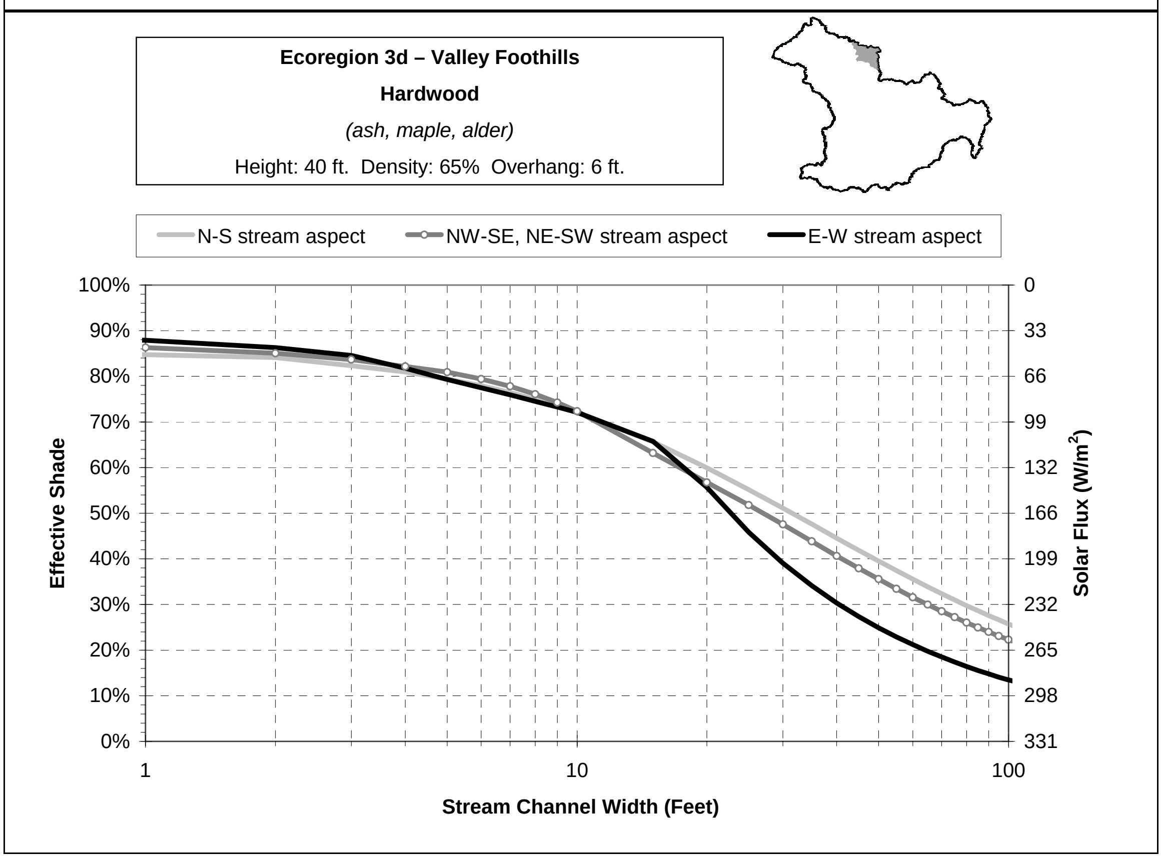
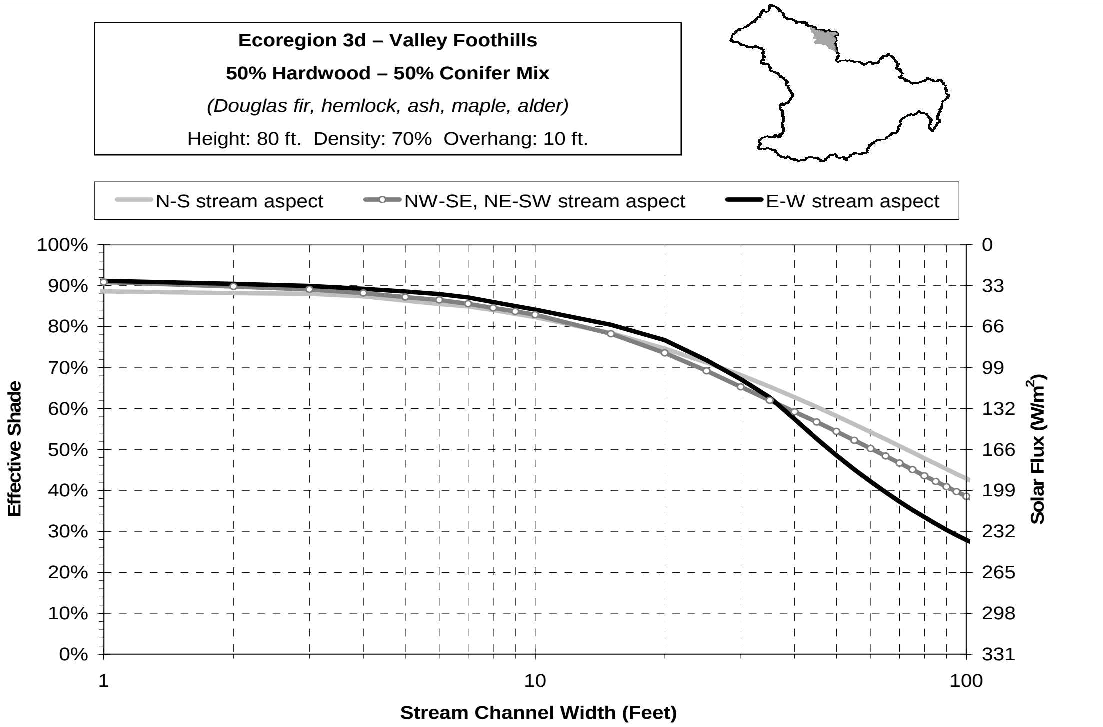
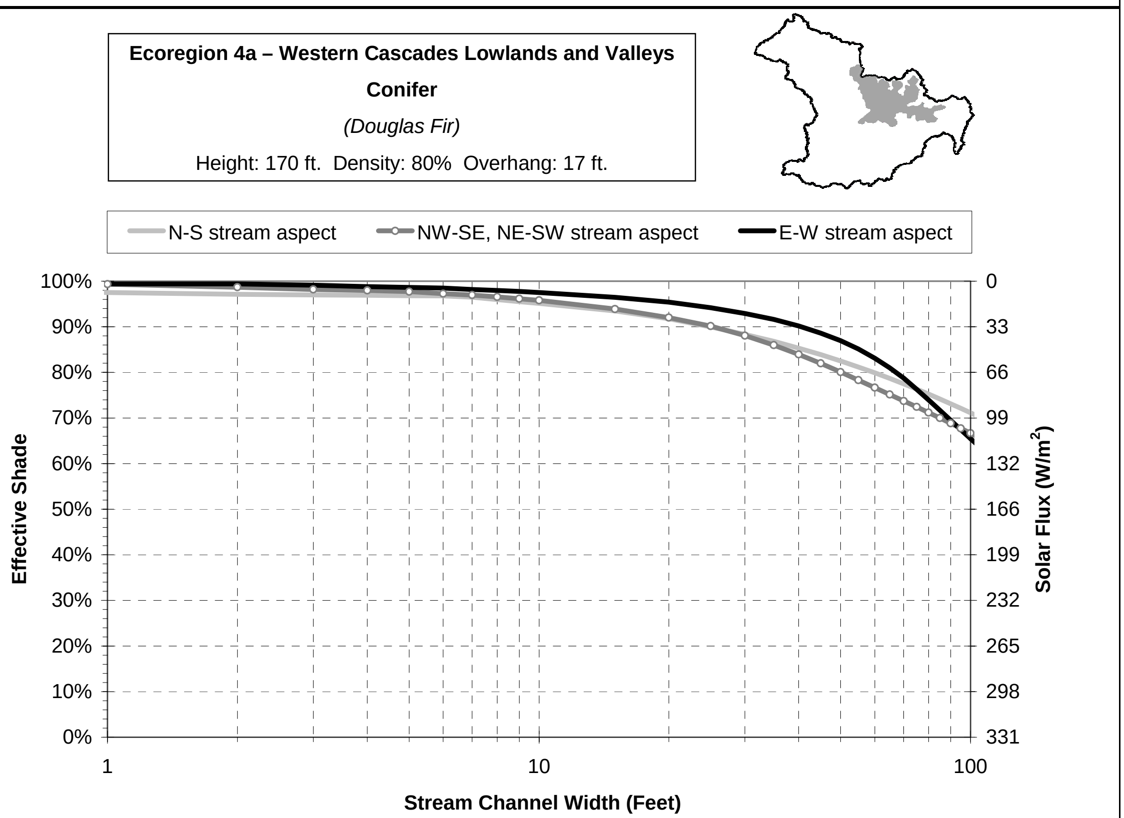


Figure 3.15 (continued). Effective Shade Curves





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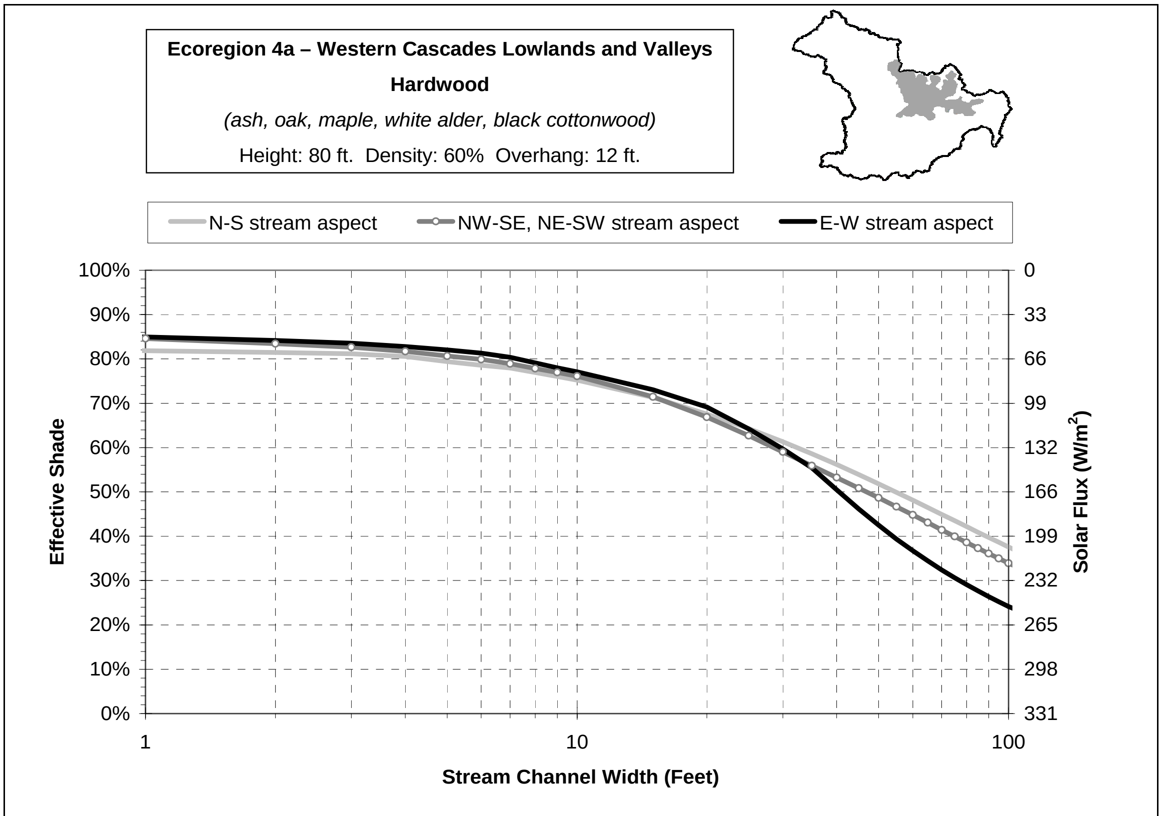


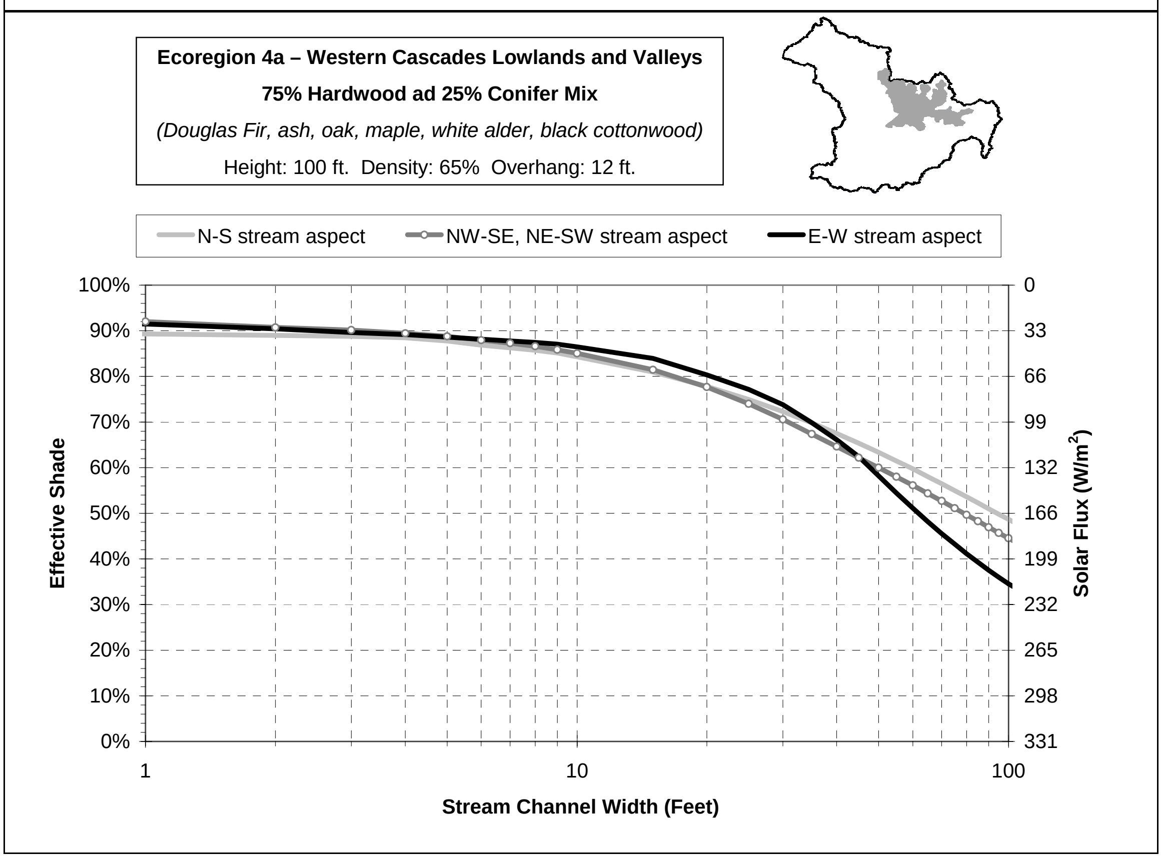
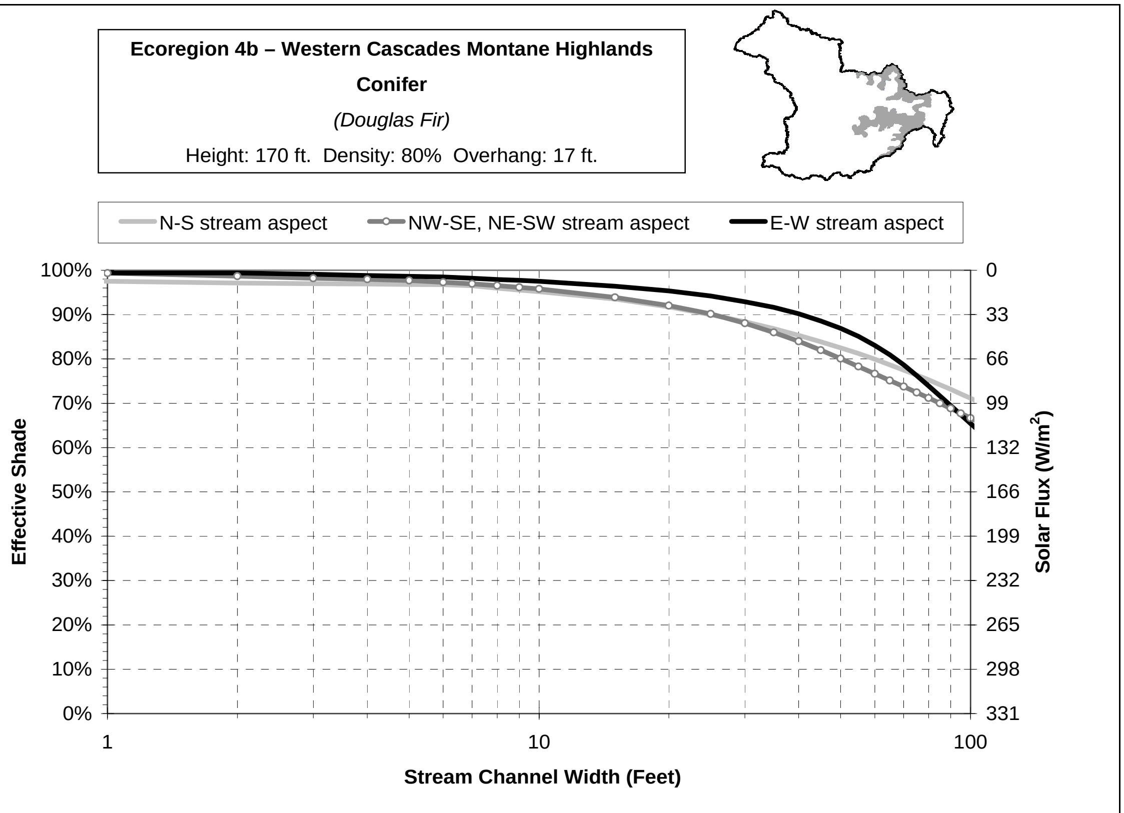
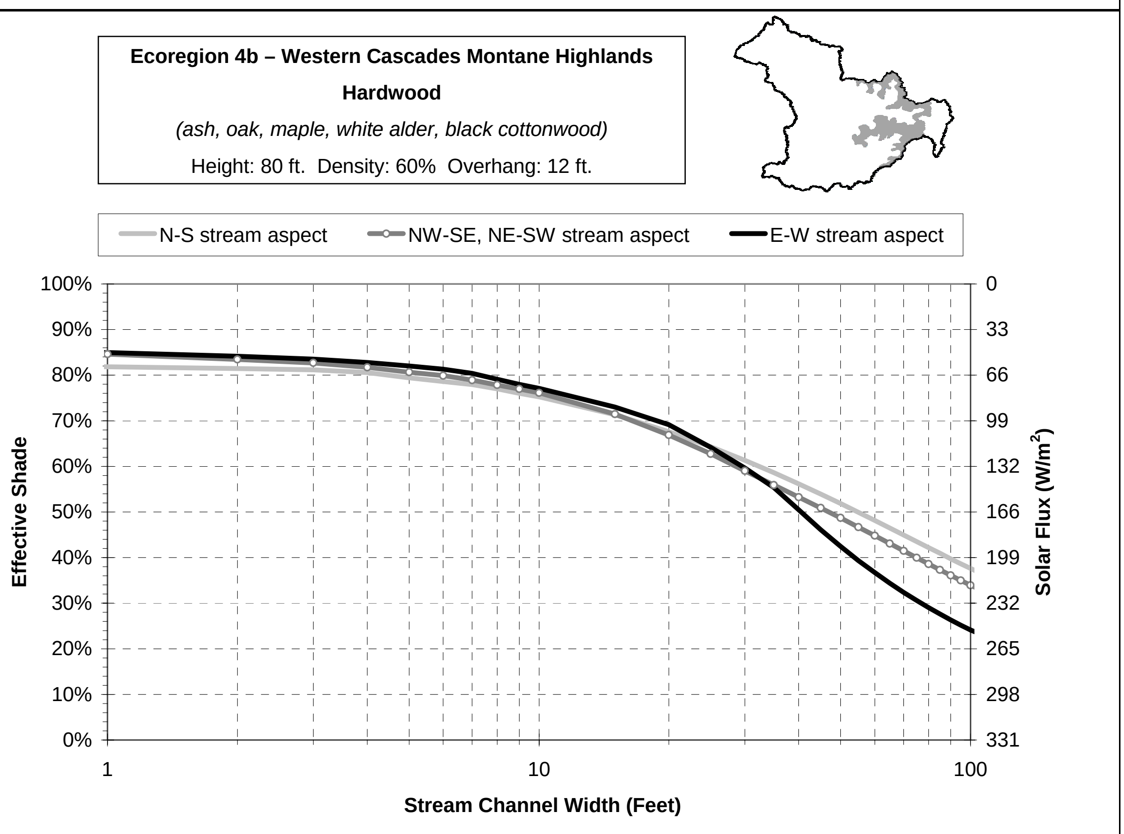


Figure 3.15 (continued). Effective Shade Curves





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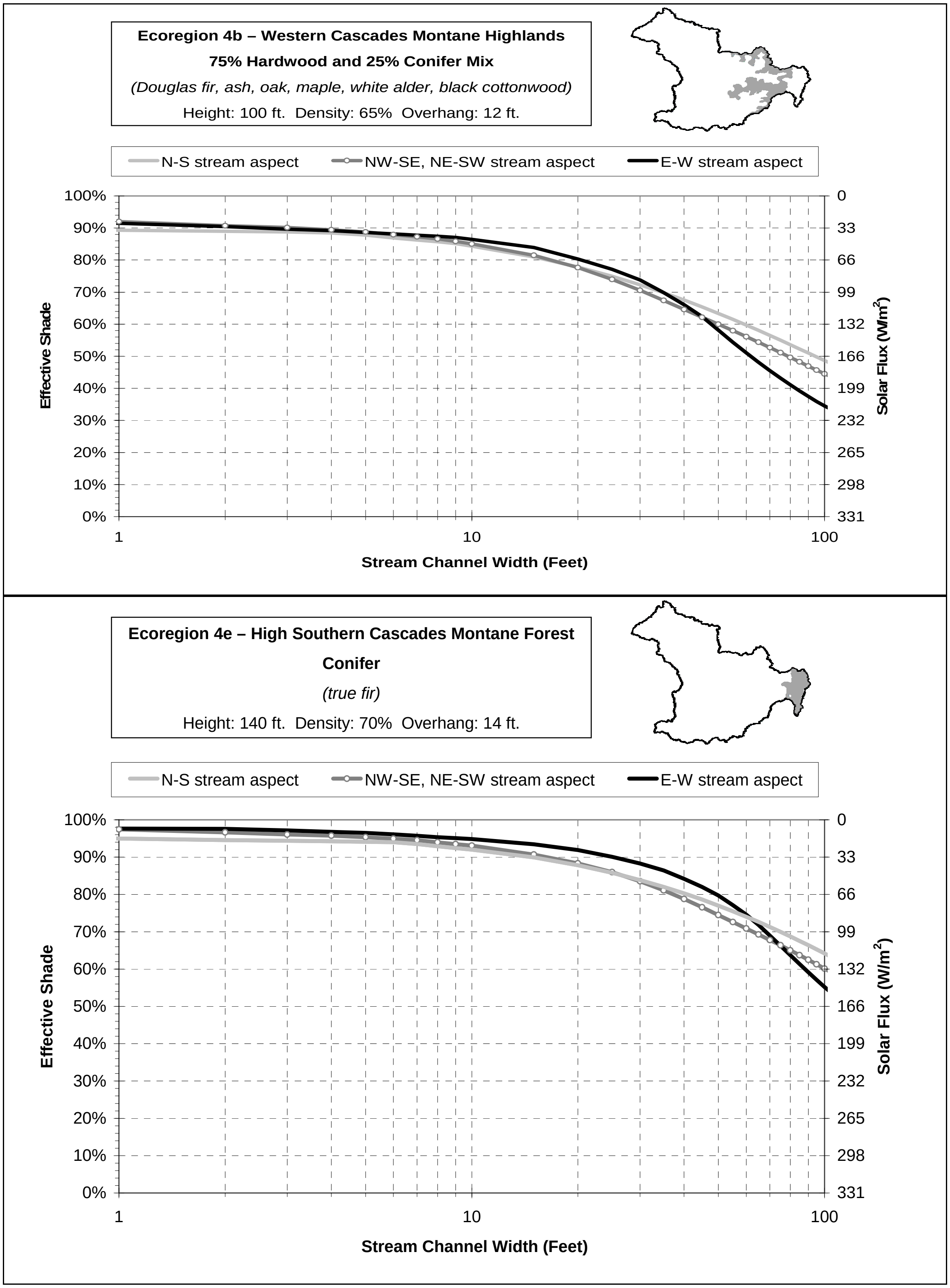
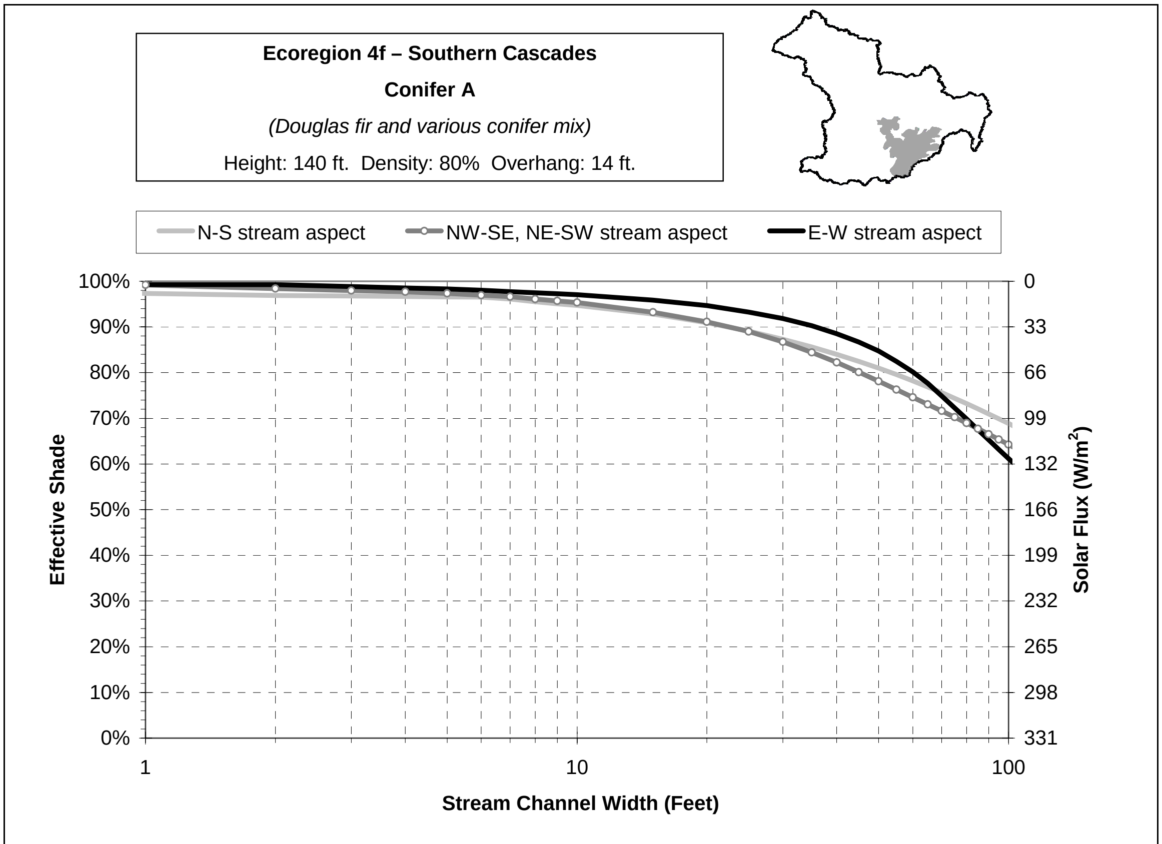


Figure 3.15 (continued). Effective Shade Curves



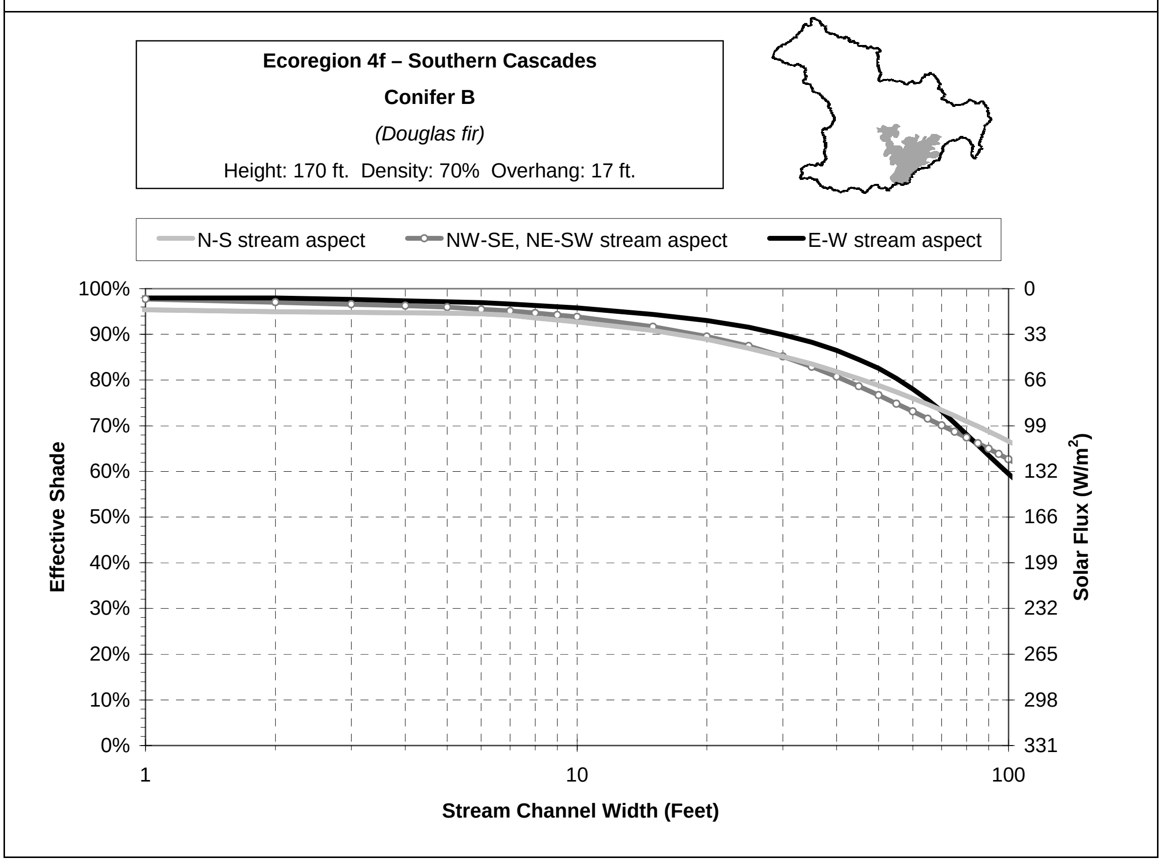
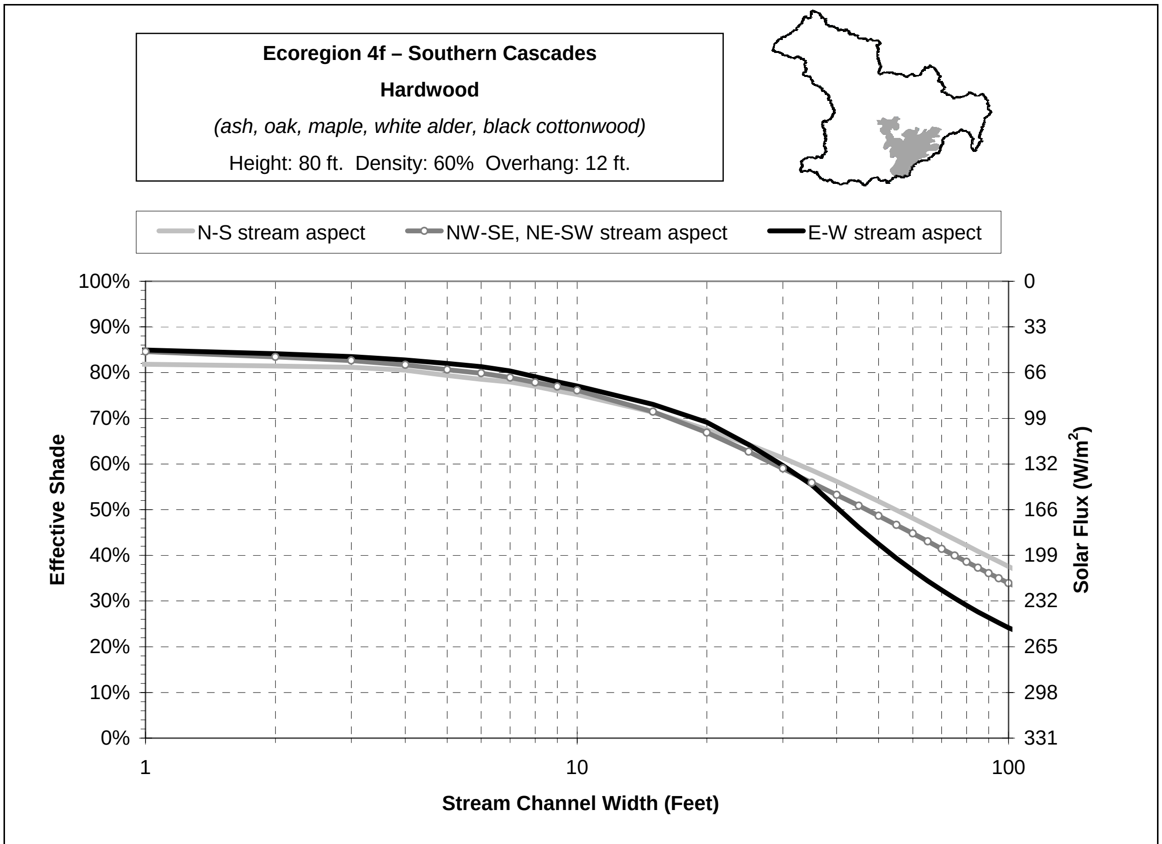
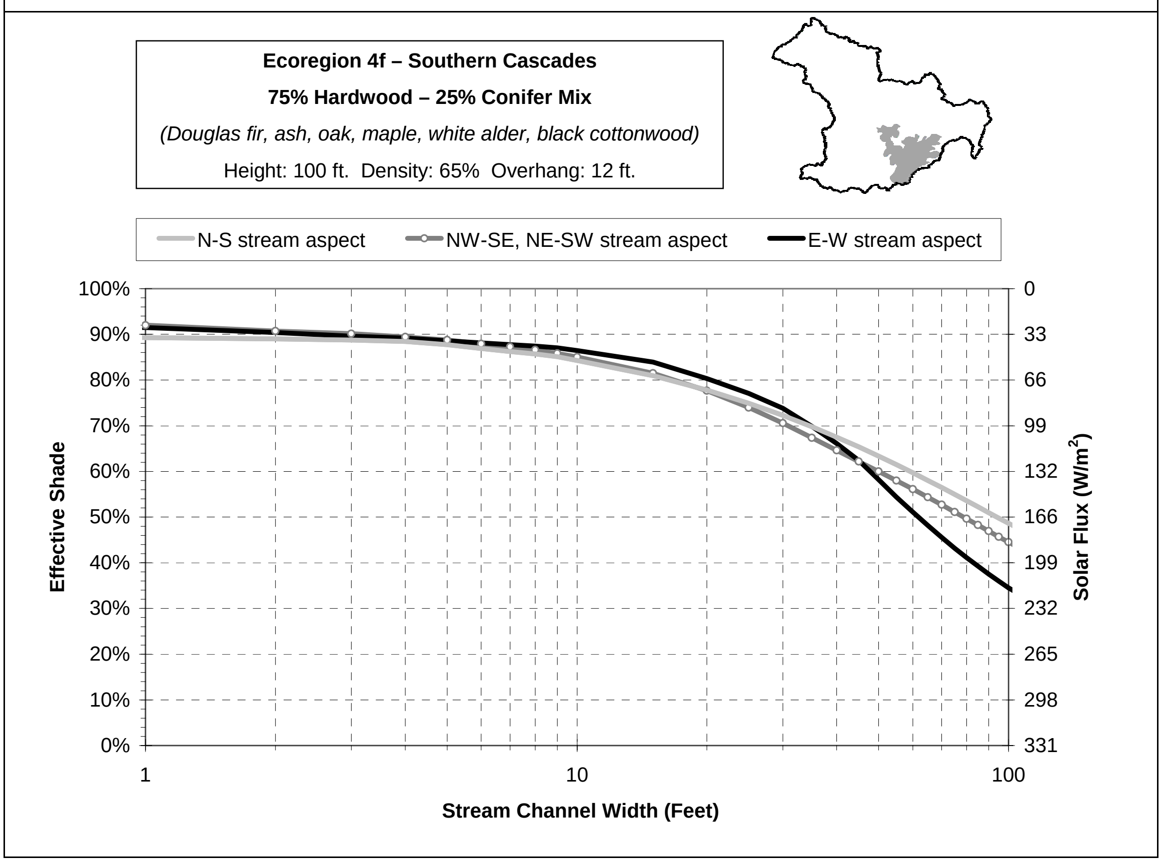


Figure 3.15 (continued). Effective Shade Curves





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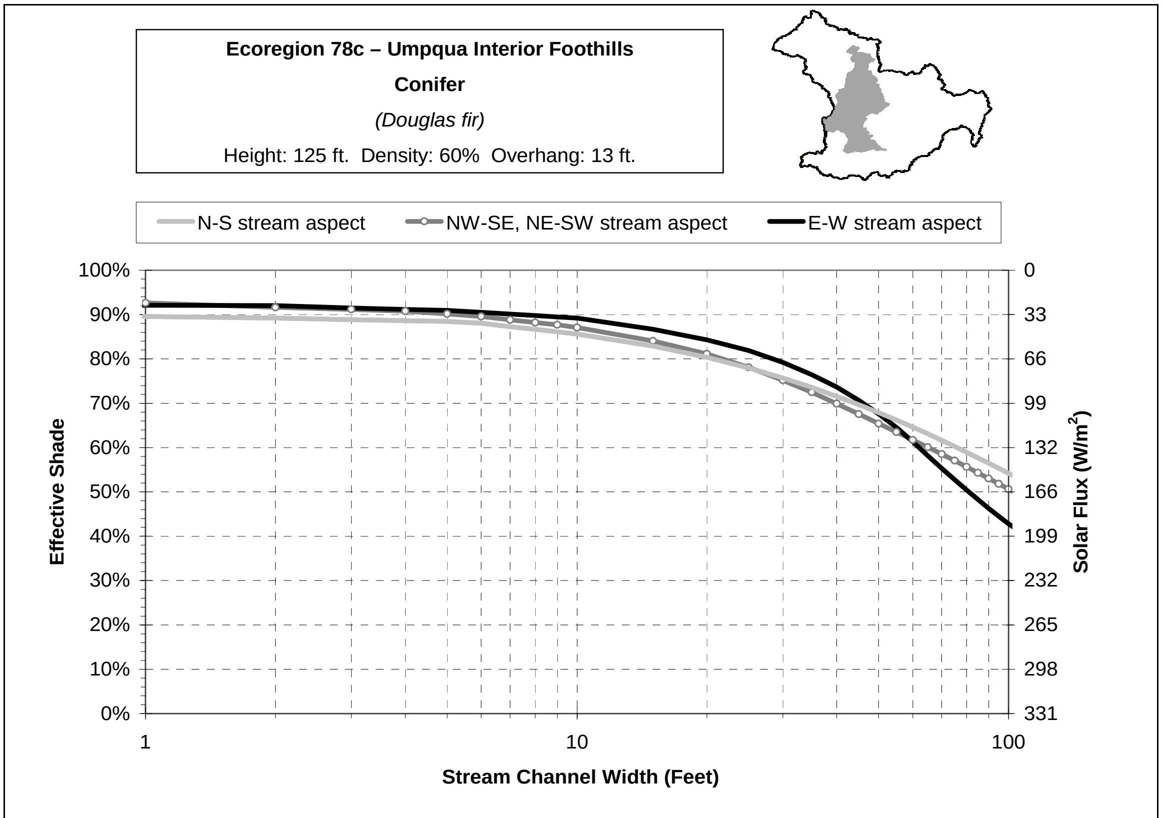

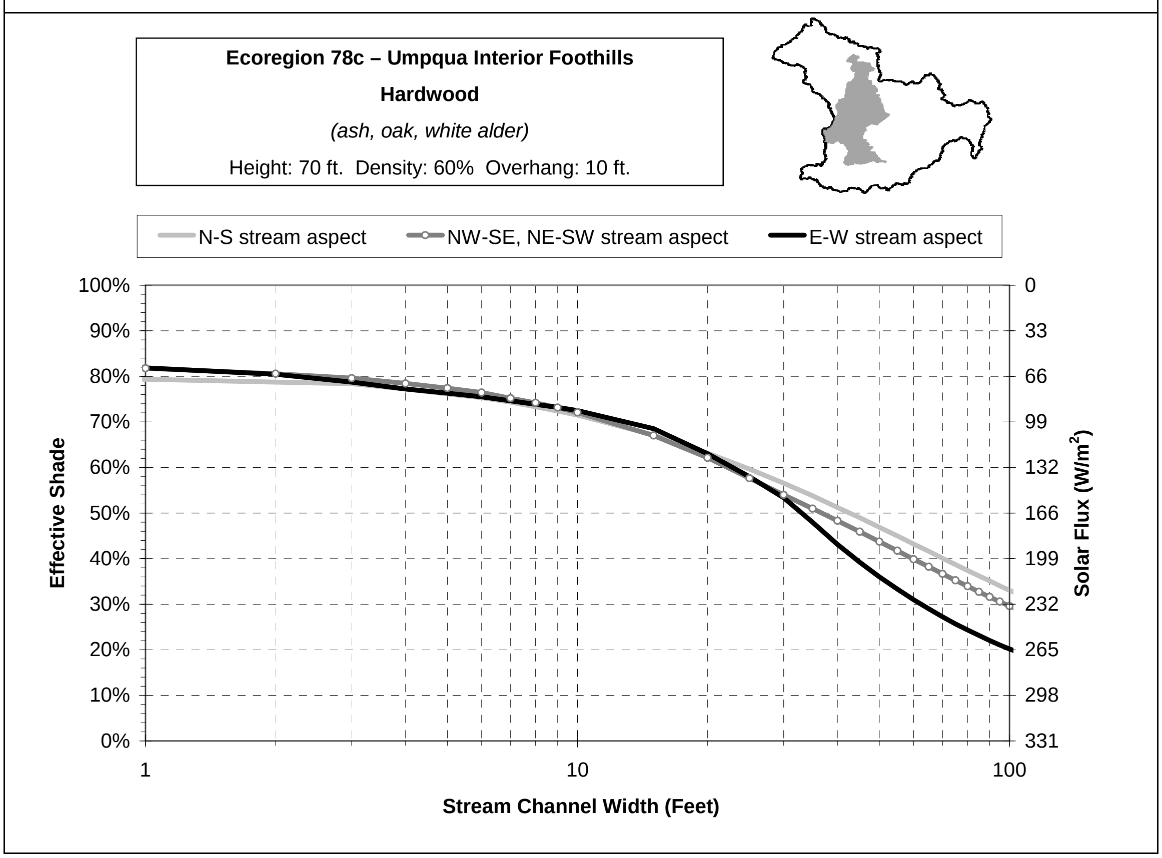

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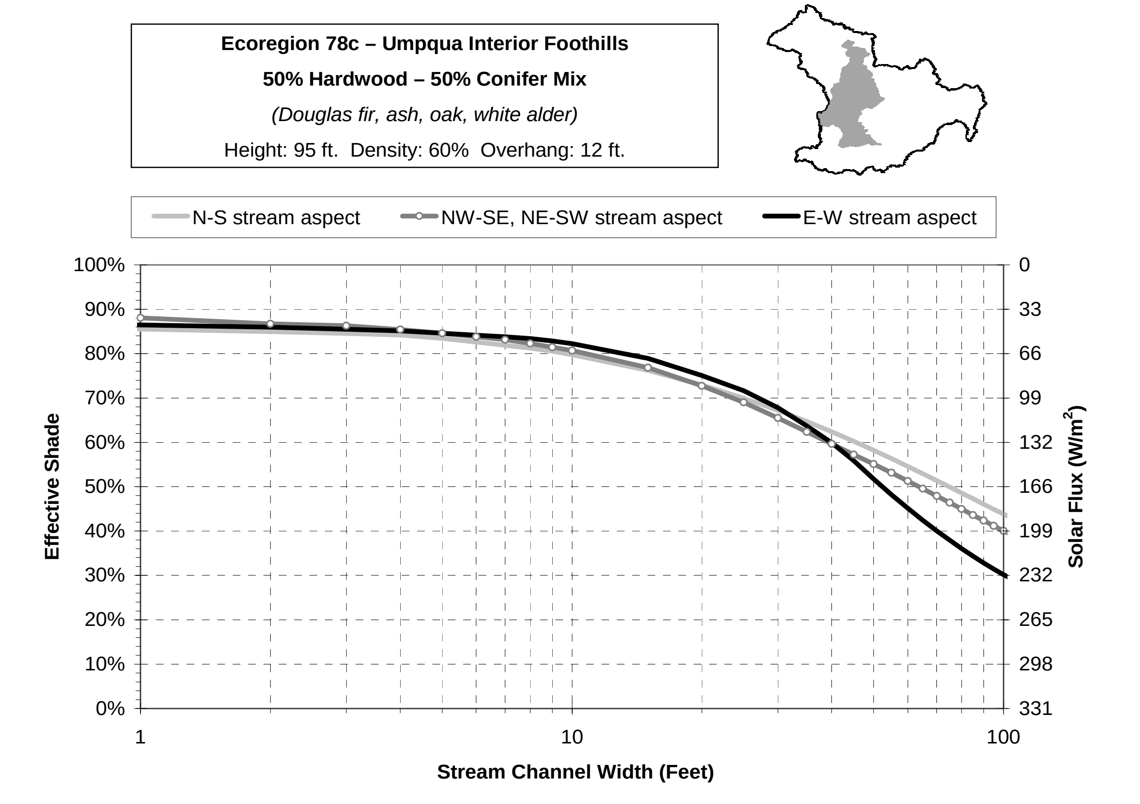


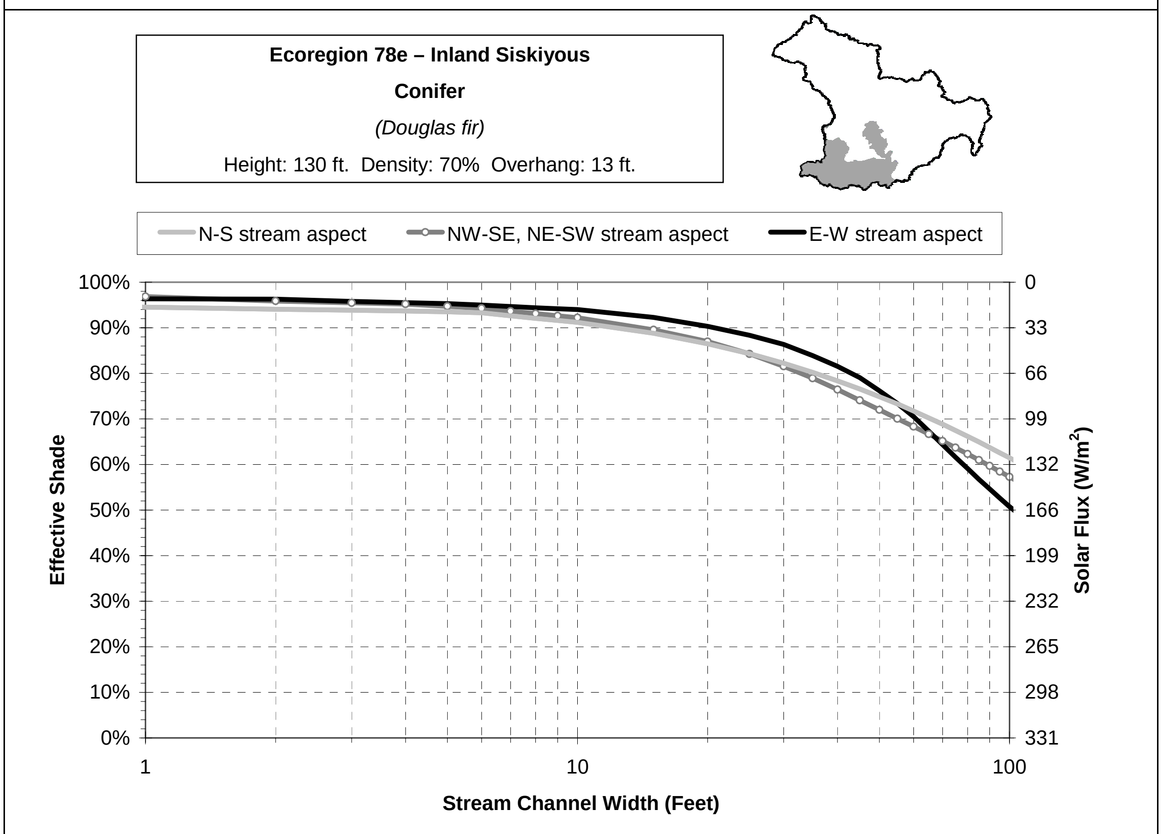
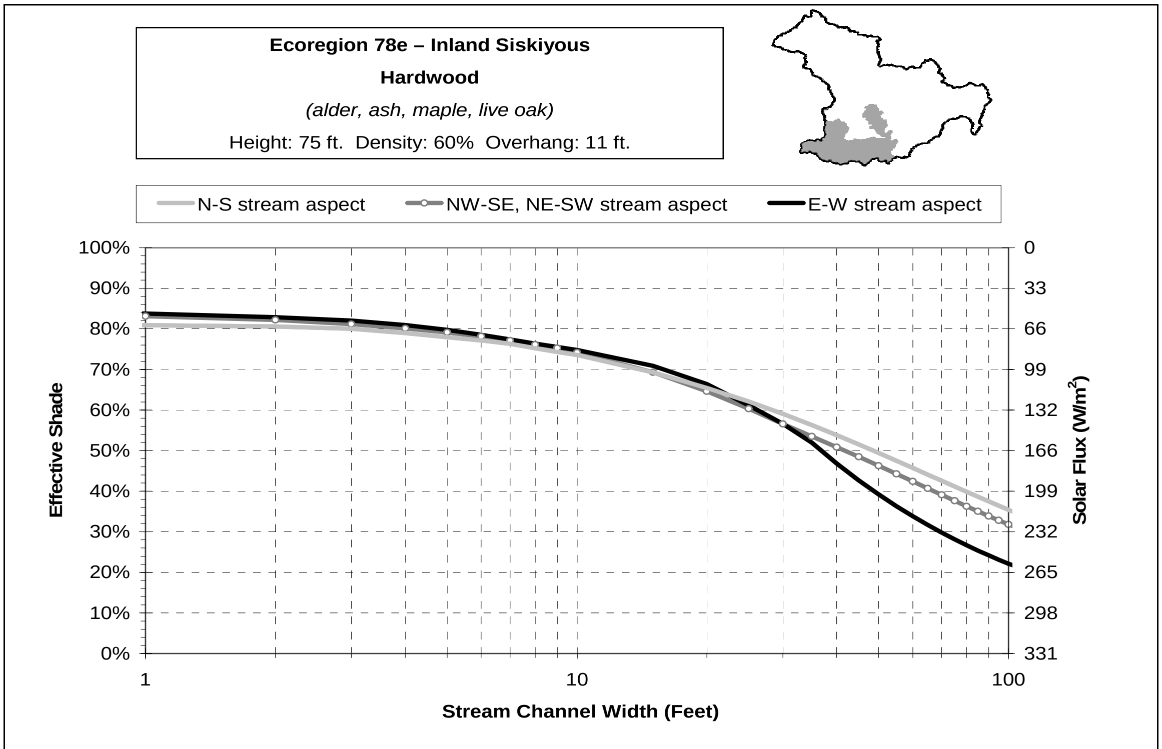


Figure 3.15 (continued). Effective Shade Curves



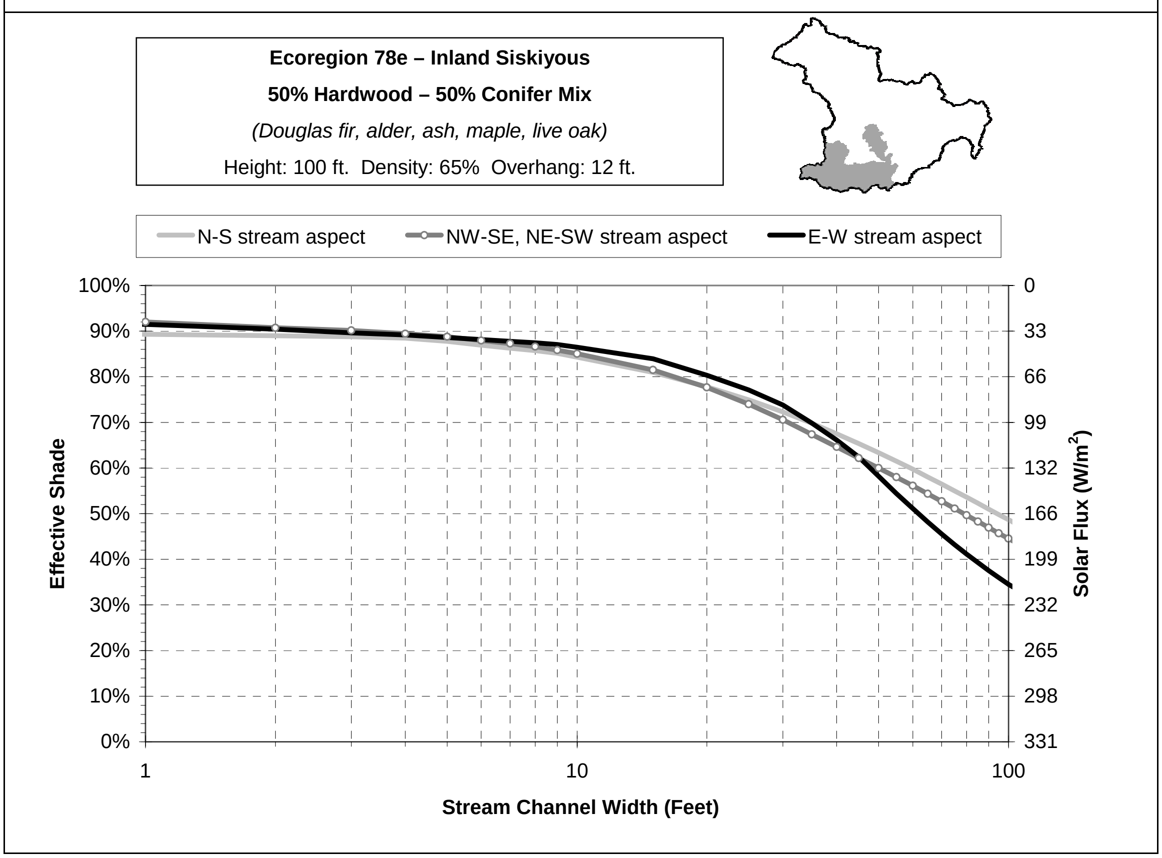


Figure 3.15 (continued). Effective Shade Curves

3.5.3 Channel Width Targets – Cow Creek

One section of Cow Creek has unusually wide channels which may have been influenced by human activities such as agriculture, road development, and reservoir operations (Figure 3.16). It is the only reach within the Umpqua River Basin Temperature TMDL that was identified as having significantly wider channel widths than would be expected under natural conditions. Targets have been developed as one of the surrogate measures.

Figure 3.16 shows the existing and targeted channel widths for Cow Creek from Galesville Reservoir (river mile 60) to the mouth. In most reaches, the current and target are the same value. River mile 50 through 41 has current channel widths that are up to 5 times wider than similar upstream and downstream areas. This section of Cow Creek flows parallel to Interstate 5. Agriculture is the dominant land use nearest the stream and that is surrounded by upland forest. Aerial photograph analysis reveals a wide, meandering channel with active scouring.

Channel widths were “capped” at 30 feet between river miles 50 and 41. This value is representative of some of the wider channel widths measured both upstream and downstream and serves as a conservative assumption within the TMDL analysis.

The natural thermal potential temperatures for Cow Creek were simulated using the channel width targets shown in Figure 3.16. Through the TMDL implementation process, ground-level assessments should be performed in cooperation with the appropriate DMAs to determine site-specific channel width targets. Ground-level channel assessments will be able to the extent that current channel widths are anthropogenically impacted.

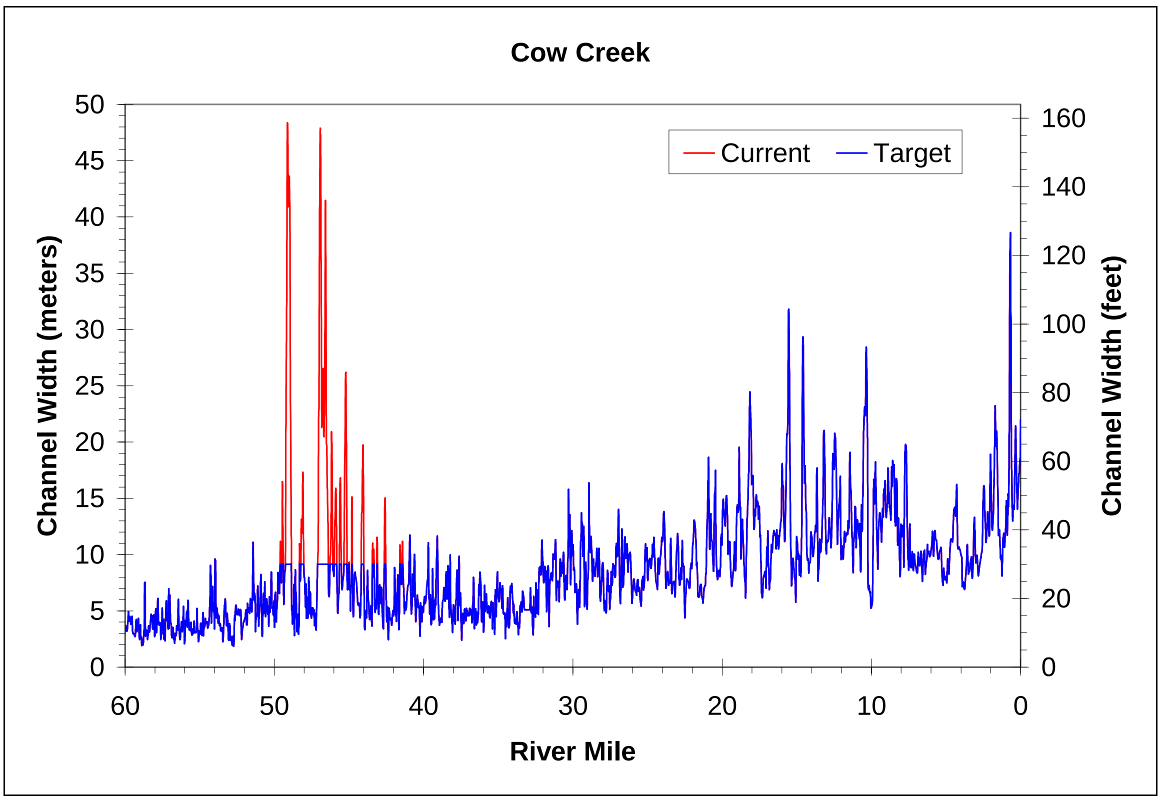


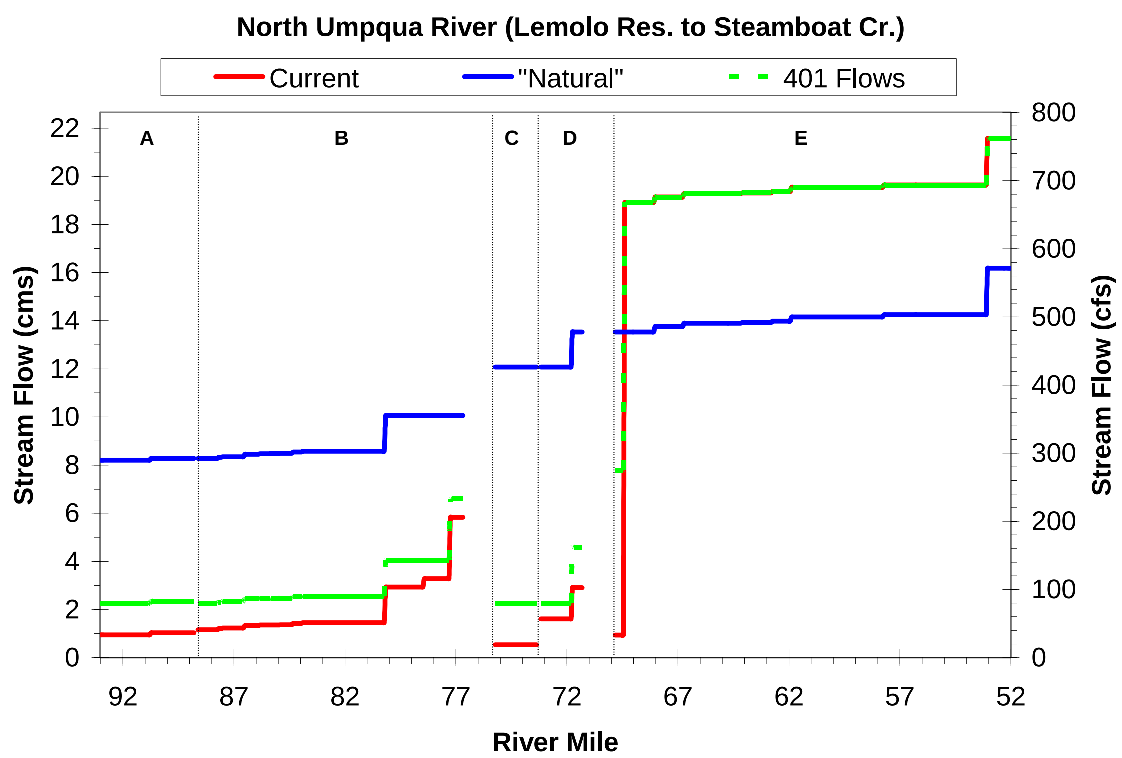
Figure 3.15 **Cow Creek Channel Widths**

3.5.3 North Umpqua River 401 Certification Flows

Attainment of the applicable temperature criteria during the critical summertime period within and downstream of the North Umpqua River hydro electric project is dependent upon implementation of the 401 certification bypass reach minimum flows. The certification flows were implemented in 2005 for the entire project; however the data for this analysis was collected previous to implementation. Attainment of the applicable spawning period temperature criteria downstream of the project has not been determined and will be completed with future TMDLs. See **Sections 3.7.8 and 3.7.21** for the temperature simulation results.

Figure 3.17 displays the current, natural, and 401 Certification Bypass reach minimum flows between Lemolo Reservoir and Steamboat Creek. The natural thermal potential stream temperature simulation was performed using the “natural” flow (i.e., no dams, diversions, or withdrawals). Since there is assimilative capacity available in these reaches, anthropogenic heat load allocations are assigned to the hydroelectric project, in the form of flow volumes that are less than “natural”.

Under the current flows, the water quality criteria are violated downstream of Soda Springs (see **Section 3.7.8**). Implementation of the 401 Certification Bypass reach minimum flows during the summertime critical period results in water quality standard attainment within the hydro project bypass reaches and everywhere downstream.



A = Lemolo #1 Dam to Lemolo #1 Power Plant – (Lmeolo Bypass Reach #1)
B = Lemolo #1 Power Plant to Toketee Dam – (Lemolo Bypass Reach #2)
C = Toketee Dam to Slide Creek Dam – (Toketee Bypass Reach)
D = Slide Creek Dam to Soda Springs Dam – (Slide Bypass Reach)
E = Soda Springs Dam to Steamboat Creek – (Soda Springs Bypass Reach and Wild & Scenic Reach)

Figure 3.16 **North Umpqua River Flow Volumes. Breaks in the longitudinal profiles occur at reservoirs.**

Clearwater River and Fish Creek are also part of the hydro electric project area. Similar flow scenarios were completed for those tributaries and the data from those simulations was used as input for the North

Umpqua River simulation. See the **Umpqua River Basin Temperature TMDL Appendix** for details regarding the flow volumes in Clearwater River and Fish Creek.

3.6 POINT SOURCE WASTE LOAD ALLOCATIONS

This TMDL addresses 22 individual NPDES permitted point sources in the Umpqua River basin (Table 3.7). The temperature TMDL for streams with point sources only applies during the rearing / migration (i.e. non-spawning) time period.

Table 3.7 Umpqua River Basin NPDES Individual Permitted Point Sources. Storm water permits not included.

Subbasin	Receiving Stream	Facility Name	Facility ID	River Mile **
Umpqua River Subbasin	Calapooya Creek	Oakland WWTP	62855	13.3
	Calapooya Creek	Sutherlin WWTP	86662	10.0
	Elk Creek	Drain WWTP	25282	23.8
	Scholfield Creek	Reedsport Landfill	103982	6.0
	Umpqua River	Brandy Bar Landing, Inc.	10696	19.8
	Umpqua River	Reedsport WWTP	74319	11.5
	Umpqua River	Winchester Bay WWTP	98090	0.6
	Yoncalla Creek	Yoncalla WWTP	99492	4.0
	Yoncalla Creek	Rice Hill East Lagoon	73705	7.5
	Yoncalla Creek	Rice Hill West Lagoon	75064	7.8
North Umpqua River Subbasin	Little River	Wolf Creek Civilian Conserv.*	90964	11.4
	North Umpqua River	Glide-Ideyld Park	33743	14.4
South Umpqua River Subbasin	Cow Creek	Glendale WWTP	33733	40.0
	Cow Creek	Riddle WWTP	75227	1.9
	South Umpqua River	Myrtle Creek WWTP	59643	38.5
	South Umpqua River	Canyonville WWTP	13745	50.7
	South Umpqua River	R.U.S.A. Roseburg WWTP	76771	7.7
	South Umpqua River	Tiller Ranger Station	90944	74.7
	South Umpqua River	Winston-Green WWTP	98400	20.6
	South Umpqua River	Roseburg Landfill	107108	14.0
	South Umpqua River	Roseburg Landfill	107108	14.0
	South Umpqua River	Roseburg Landfill	107108	14.0

*Refer to The Little River Watershed TMDL (ODEQ, 2001, approved by EPA 2002) for the waste load allocations.
** River miles based on temperature model and may vary from maps.

Thermal waste load allocations are calculated to ensure that a point source will not increase stream temperatures beyond the applicable criterion more than 0.1^{o}C (cumulatively) at the stream's point of maximum impact. Points of maximum impact are locations where the greatest thermal impact is observed in the stream. These locations vary spatially and temporally.

Temperature modeling was only performed for the summertime critical period and the thermal waste load allocations for this period are calculated based on their near-field impacts (i.e., their impacts on stream temperature at the effluent source). Far-field thermal impacts from point sources were not observed in the simulations due to the limited number and relatively small sizes of the point sources in the Umpqua River Basin. For this reason, the point of maximum impact is considered to be at the point of discharge for each individual point source effluent during the critical summertime period. All calculations assume 100% of the river is used for dilution.

Table 3.8 summarizes the summertime critical period Waste Load Allocations for point sources located on streams that were simulated as part of this TMDL analysis. In order to simulate a worst case scenario, facility dry weather design flow was used. The values in the table were used as inputs to the Natural Thermal Potential stream temperature simulation and it was observed that the Human Use Allowance was not exceeded at any point of maximum impact. Note that the example Waste Load Allocations presented in Table 3.8 are applicable only to the summertime critical period and the facility dry weather design flow. Facilities with storm water permits and landfills do not typically discharge during the critical period and are not included in the table.

The NPDES permit renewal process will incorporate the waste load allocations for the non-spawning time period using Equations 4-1 and 4-2 (see insert below) of which Table 3.8 is an example for the critical temperature period. Since waste load allocations are flow-dependent, effluent limits will be variable over time and will be designated source by source. The applicable temperature criterion used to calculate the effluent temperature limit may be the numeric criterion in the standard or natural thermal potential. For some rivers (i.e. South Umpqua River from mouth to river mile 100 and Cow Creek from mouth to river mile 35) the current conditions are similar to natural thermal potential for the critical time period. Therefore, it would be appropriate to use current conditions as an estimate of natural thermal potential for the non-spawning time period. NPDES permits for point sources must also meet the mixing zone and temperature thermal plume limitations described in OAR 340-041-0053. Some sources may not be able to fully utilize their waste load allocations under these limitations. The limitations, if any, will be applied during the permit renewal process.

There is one point source, Glide-Ideyld WWTP, which discharges to a reach that was identified as impaired for temperature during the spawning period on the 2004/06 303(d) list. Due to data limitations, a TMDL cannot be completed at this time. As the 303(d) is updated, additional reaches may be identified as impaired for temperature during the spawning period. The water quality standards, OAR-340-041-0028(12)(b)(A), state the amount of temperature increase a point source may contribute prior to a TMDL on a temperature impaired stream. As discussed above, during the summer, the current temperature is a good estimate of natural thermal potential for the South Umpqua River and Cow Creek. As long as reservoir operations do not dramatically alter system hydrology, it is likely that current conditions will also be similar to natural thermal potential for other periods of the year. Therefore, natural thermal potential can be adequately estimated using current conditions for the purposes of determining thermal loads for times other than the critical period for the above and similar reaches.

Table 3.8 Example Waste Load Allocation Calculations for Point Sources on Simulated Streams using Dry Weather Design Flows and Natural Thermal Potential Stream Conditions.

Facility Name	River Mile	Dry Weather Design Flow (cms) Q_{PS}	River Flow from Natural Thermal Potential Simulation (cms) Q_R	Natural Thermal Potential River Temperature (7-Day Average Maximum, ^oC) T_R	Allocated Portion of the Human Use Allowance (^oC) HUA	Waste Load Allocation (MW) H_{WLA}	Effluent Temperature Limit (^oC) T_{WLA}
Oakland WWTP	13.3	0.005	0.263	27.0	0.1	0.112	32.9 (32.0)*
Sutherlin WWTP	10	0.057	0.263	25.9	0.1	0.134	26.4
Drain WWTP	23.8	0.013	0.129	24.4	0.1	0.06	25.5
Glide-Ideyld Park	14.4	0.012	28	21.8	0.1	11.733	251.8 (32.0)*
Glendale WWTP	40.04	0.011	0.78	23.1	0.1	0.331	30.3
Riddle WWTP	1.9	0.011	2	23	0.1	0.842	41.7 (32.0)*
Myrtle Creek WWTP	38.5	0.079	2.9	26.2	0.1	1.248	30.0
Canyonville WWTP	50.7	0.022	2	27.5	0.1	0.847	36.8 (32.0)*
R.U.S.A. Roseburg WWTP	7.7	0.346	3.2	27.3	0.1	1.485	28.3
Tiller Ranger Station	74.7	0.001	1.6	23.5	0.1	0.671	164.8 (32.0)*
Winston-Green WWTP	20.6	0.070	3.1	27.5	0.1	1.328	32.0

* Under the thermal plume limitations described in 340-041-0053 (1)(d), discharge temperatures are limited to 32.0 C to prevent acute impairment or instantaneous lethality to salmonids. Other discharge limitations may apply within OAR 340-041-0053.

Umpqua River Basin Thermal Waste Load Allocations

Thermal waste load allocations are expressed as heat loads, which are dependent upon upstream river flow and effluent flow. Effluent flow and river flow change over time. The following equation is used to calculate the thermal waste load allocations in the Umpqua River basin for any given effluent flow and river flow.

$$H_{WLA} = (HUA)(Q_{PS} + Q_R)(c)/1{,}000{,}000 \quad (4\text{-}1)$$

Where,

H_{WLA} = Waste Load Allocation Heat Load (MW)
Q_{PS} = Point Source Effluent Flow (cms)
Q_R = Upstream River Flow (cms)
HUA = Human Use Allowance (^oC)
c = Specific Heat of Water = 1.0 cal/g*C = 4.1868 x 10^6 J/m^3*C
1,000,000 = conversion factor from J/sec to MW

In order to translate a thermal waste load allocation into an effluent temperature, the applicable temperature criterion must also be accounted for. The applicable temperature criterion is either the biologically based numeric criteria presented in OAR 340-041-0028(4) or the natural thermal potential, if it has been calculated for that receiving water body during the applicable time period. The following equation is used to calculate the effluent temperature limit for any given effluent flow, river flow, and river temperature.

$$T_{WLA} = \frac{(Q_{PS} + Q_R)(T_R + HUA) - (Q_R)(T_R)}{Q_{PS}} \quad (4\text{-}2)$$

Where,

T_{WLA} = Waste Load Allocation Temperature (^oC)
Q_{PS} = Point Source Effluent Flow (cms)
Q_R = Upstream River Flow (cms)
T_R = Applicable Temperature Criterion or Upstream Natural Thermal Potential (^oC)
HUA = Human Use Allowance (^oC)

Assumptions:

- Mixing uses 100% of river flow.
- The portion of the Human Use Allowance (HUA) allocated to point sources is 0.1^{o}C above the applicable criterion, cumulatively at the point of maximum impact.

Additional Considerations:

- Some facilities currently do not discharge to the stream during the summer. Under such circumstances, the facility will meet its waste load allocation by default.
- For the South Umpqua River (mouth to river mile 100) and Cow Creek (mouth to river mile 35) current conditions are similar to natural thermal potential for the critical time period.

Figure 3.18 shows how thermal waste load allocations (effluent heat load limits) are variable according to the upstream river flow. Larger dilution ratios result in higher thermal waste load allocations. Table 3.9 shows the corresponding example effluent temperature limits which are dependent upon upstream river temperature and flow.

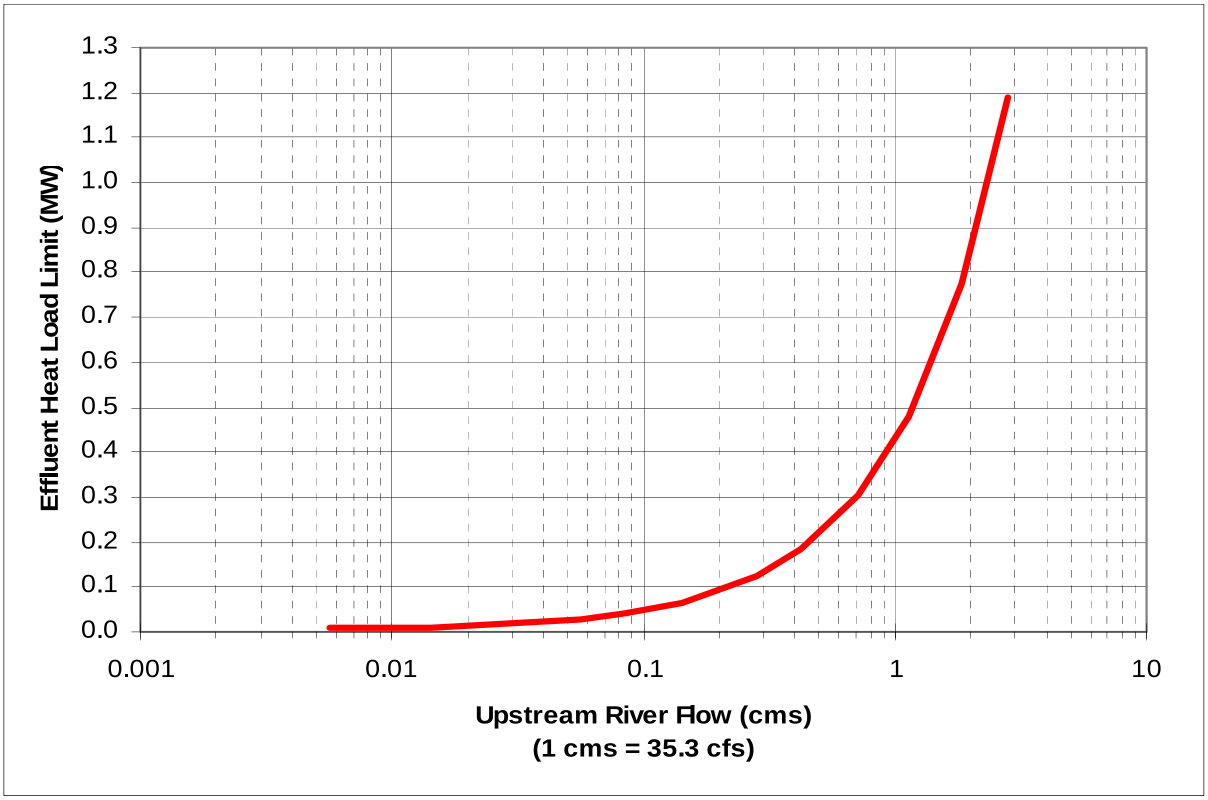


Figure 3.17 **Example Waste Load Allocations for a 0.30 MGD Point Source (based on 0.1*C Human Use Allowance).**

Table 3.9 Example Temperature Effluent Limits for 0.30 MGD Point Source 0.1°C Human Use Allowance). Upstream river temperature refers to the upstream natural thermal potential temperature.

Upstream River Flow (cms)	Upstream River Temperature (°C)								Effluent Heat Load Limit (Megawatts)
	10.0	12.8	15.6	18.3	21.1	23.9	26.7	29.4	
	Effluent Temperature Limits (°C)								
0.01	10.1	12.9	15.7	18.5	21.3	24.0	26.8	29.6	0.008
0.01	10.2	13.0	15.8	18.5	21.3	24.1	26.9	29.7	0.011
0.03	10.3	13.1	15.9	18.6	21.4	24.2	27.0	29.8	0.017
0.06	10.5	13.3	16.1	18.9	21.6	24.4	27.2	30.0	0.029
0.08	10.7	13.5	16.3	19.1	21.9	24.6	27.4	30.2	0.041
0.14	11.2	14.0	16.7	19.5	22.3	25.1	27.8	30.6	0.065
0.28	12.3	15.0	17.8	20.6	23.4	26.1	28.9	31.7	0.124
0.42	13.3	16.1	18.9	21.7	24.4	27.2	30.0	32.8	0.183
0.71	15.5	18.3	21.0	23.8	26.6	29.4	32.2	34.9	0.302
1.13	18.7	21.5	24.3	27.1	29.8	32.6	35.4	38.2	0.480
1.84	24.1	26.9	29.7	32.4	35.2	38.0	40.8	43.5	0.776
2.83	31.6	34.4	37.2	40.0	42.8	45.5	48.3	51.1	1.192

3.7 TEMPERATURE SIMULATION RESULTS (ATTAINMENT)

Simulations were performed to estimate the natural thermal potential stream temperatures. The resulting simulated natural thermal potential stream temperatures were used to identify streams with existing assimilative capacity and to determine the appropriate TMDL allocations.

Assimilative capacity is the amount of pollutant above the background level that a waterbody can receive without exceeding water quality standards. Assimilative capacity is equivalent to the heat load above background level that can be allocated to nonpoint and point sources.

Table 3.10 summarizes the assimilative capacity and anthropogenic nonpoint source load allocations for each stream simulated.

Table 3.10 Assimilative Capacity Availability for Anthropogenic Nonpoint Source Load Allocations

Stream	Assimilative Capacity Available (Yes/No)	Anthropogenic Nonpoint Source Load Allocation[6] (Megawatts)
Jackson Creek	No	0
Cow Creek	See Section 3.7.2	See Section 3.4
Olalla-Lookingglass Creek	See Section 3.7.3	See Section 3.4
South Umpqua River	No	0
Lake Creek	No	0
Fish Creek	See Section 3.7.7	See Section 3.4
North Umpqua River (Lemolo Res. to Steamboat Cr.)	See Section 3.7.8	See Section 3.4
Canton Creek	No	0
Steamboat Creek	No	0
Rock Creek	No	0
North Umpqua River (Steamboat Cr. to Mouth)	No	0
Calapooya Creek	No	0
Elk Creek	No	0
Umpqua River (Forks to Tidewater)	No	0
North Fork Smith River	See Section 3.7.18	See Section 3.4
West Fork Smith River	See Section 3.7.19	See Section 3.4
Smith River	No	0

A total of 650 stream miles in the Umpqua River Basin were analyzed and simulated during the critical summertime period. The following pages compare the current stream temperatures with the natural thermal potential for each stream modeled.

Unless specified otherwise, the natural thermal potential stream temperatures were simulated using the following:

Potential vegetation heights and densities – including natural disturbance estimates.
Natural flow conditions – no dams, no withdrawals, no point sources.
Potential tributary temperatures.

Further discussion about the simulation methodology is included within the **Umpqua River Basin Temperature TMDL Appendix.**

[6] Excludes the human use allowance, equivalent to a cumulative 0.1°C increase at the point of maximum impact.

Figure 3.19 shows the streams that were simulated as part of this TMDL analysis. The simulations strived to simulate the stream network as a whole. Simulation outputs were used as inputs into their receiving water's model. For example, outputs from the Rock Creek simulation were used as tributary inputs in the North Umpqua River model. The North Umpqua River model outputs were then used as inputs to the Umpqua River model. Stream simulations were completed for different years based on the availability of data.

Reservoirs and backwaters behind dams were not simulated because Heat Source is not an appropriate model for simulating stratified non-moving waters.

In the lower basin, stream simulations were stopped at points where tidal influences are present. Water quality standards still apply within tidally influenced stream reaches; however, Heat Source is not capable of simulating those conditions.

Point sources were included as inputs within the stream temperature models. As previously mentioned, most point sources currently have little or no measurable impact on current stream temperatures. Waste load allocations were calculated so that each point source has a maximum of 0.1°C impact within their mixing zones and cumulatively within the basin.

For more information regarding stream temperature modeling, read **The Umpqua River Basin Temperature TMDL Appendix**.

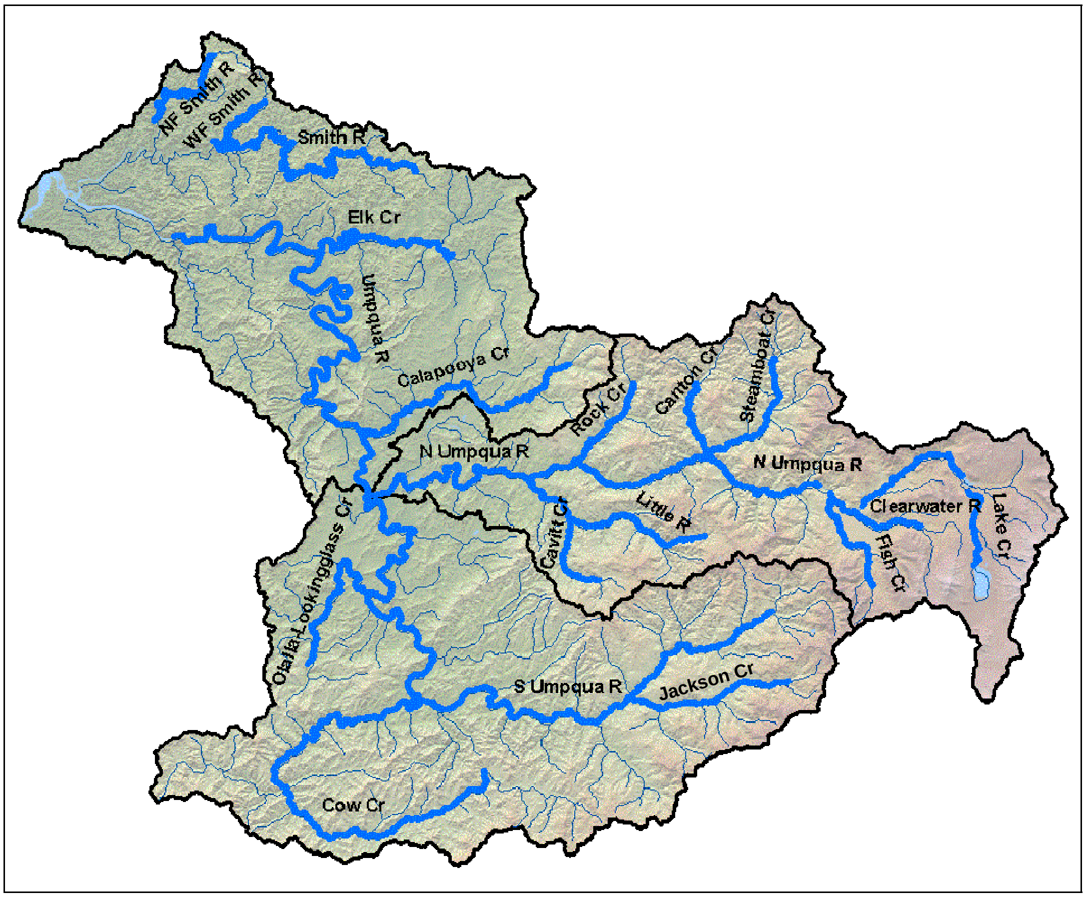


Figure 3.18 **Streams Simulated in the Umpqua River Basin**

3.7.1 Jackson Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Jackson Creek.

Wildfires were burning during this time period and the Jackson Creek Watershed was smoky. However, the smoke did not interfere with the quality of the TIR data[7].

The upper reaches of Jackson Creek are heavily forested with mature conifers, and shade levels are currently at or near their potential. As a result, the current stream temperature is close to the natural thermal potential. Within the lower 14 river miles, anthropogenic activities (i.e., logging, road development, etc.) have reduced effective shade levels and the result is that the current 7-day average maximum temperature at the mouth is approximately 3°C warmer than the natural thermal potential.

River mile 11.3 is the confluence of Squaw Creek. Squaw Creek contributes about 20% of the flow at that point in Jackson Creek and is much cooler, resulting in a notable temperature decrease.

The natural thermal potential temperature exceeds the numeric criterion (16°C) so there is no assimilative capacity for Jackson Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

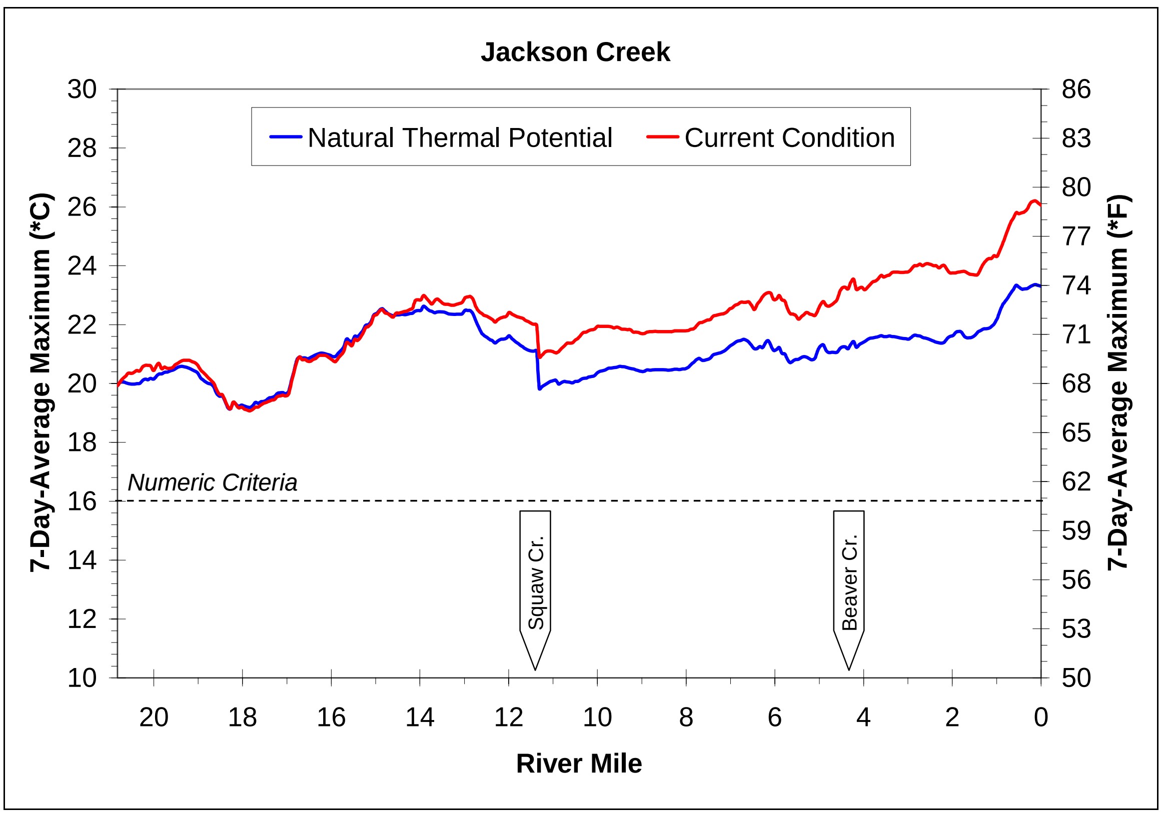


Figure 3.19 **Jackson Creek temperature simulation results.**

[7] **Watershed Sciences, Inc. 2003.** *Aerial Surveys in the Umpqua River Basin: Thermal Infrared and Color Videography*. Corvallis, OR. (May be downloaded at www.deq.state.or.us)

3.7.2 Cow Creek

Heat Source simulations were performed for July 12-31, 2000. These temperatures represent the summertime critical period for Cow Creek. The analysis extended from the mouth to Galesville Reservoir based on the availability of data.

Cow Creek included channel width targets within the NTP simulations between river miles 50 and 41. It is the only location in the basin which received channel width targets as part of the surrogate measure for the load allocation. **Section 3.5.3** discusses the channel width targets.

Since the Galesville Reservoir construction in 1986, Cow Creek's summer flow regime has been augmented. The natural thermal potential simulation was performed using boundary conditions and temperatures that would exist without the reservoir (based on historical data and recently measured data at the reservoir inlet). Those conditions result in lower discharge and warmer temperatures; hence the natural thermal potential is warmer than the current stream temperatures in many reaches below the reservoir. It is undetermined how Galesville Reservoir influences stream temperatures during the salmon and steelhead spawning period. This will be addressed in a future TMDL as more data is collected.

Changes in channel morphology and groundwater result in a temperature decrease near river mile 35. The temperature decrease is more pronounced in the natural thermal potential simulation because the stream flow is less than the current condition. Likewise, the entire natural thermal potential temperature profile exhibits more variability than the current condition.

The natural thermal potential temperature exceeds the numeric criteria (16°C upstream of river mile 30 and 18°C downstream of river mile 30). Since the NTP is warmer than the numeric criterion, it becomes the new criteria. Additionally, since the current condition is cooler than the NTP between Galesville Reservoir and river mile 35, there may be assimilative capacity available.

Anthropogenic sources could potentially increase stream temperatures in reaches where the current condition is cooler than the NTP as long as…

- the NTP is not exceeded at any time at any location,
- downstream reaches that are currently below the NTP are not caused to exceed the NTP,
- downstream reaches that are currently warmer than the NTP do not increase more than the allocated human use allowance of 0.2°C, and
- there are no threatened or endangered salmonids.

The nonpoint source load allocation consists of a portion of the assimilative capacity plus 0.1°C human use allowance. (Assimilative capacity may be shared with point sources.)

Coho salmon are proposed to be listed as a "threatened" under the Endangered Species Act by the National Marine Fisheries Service (NMFS). In the event that Coho salmon are officially listed as threatened, the cold water protection narrative portion of Oregon's stream temperature standard may apply during times of the year. It reads, "*waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present*". (OAR Chapter 340, Division 41)

The assimilative capacity (and load allocation) of Cow Creek is not quantified within this TMDL. The amount of solar heat load required to increase temperatures up to the NTP is variable both temporally and spatially. For example, a specific heat load may cause a 1 degree increase at river mile 50, but the same heat load may cause a 2 degree increase at river mile 40. In addition, different seasons and different flow regimes will affect the amount of heat necessary to increase stream temperatures.

Flow volume may also be considered a "source" of temperature increases. For example, if releases from Galesville Reservoir were reduced by 50% during the simulation period, stream temperatures would be warmer. Such a scenario would effectively be using a portion of the available assimilative capacity.

TMDL implementation must ensure that all anthropogenic sources (those influencing flow and those influencing effective shade) do not cumulatively cause violations of the applicable criteria anywhere along Cow Creek or in other downstream reaches within the Umpqua River Basin stream network.

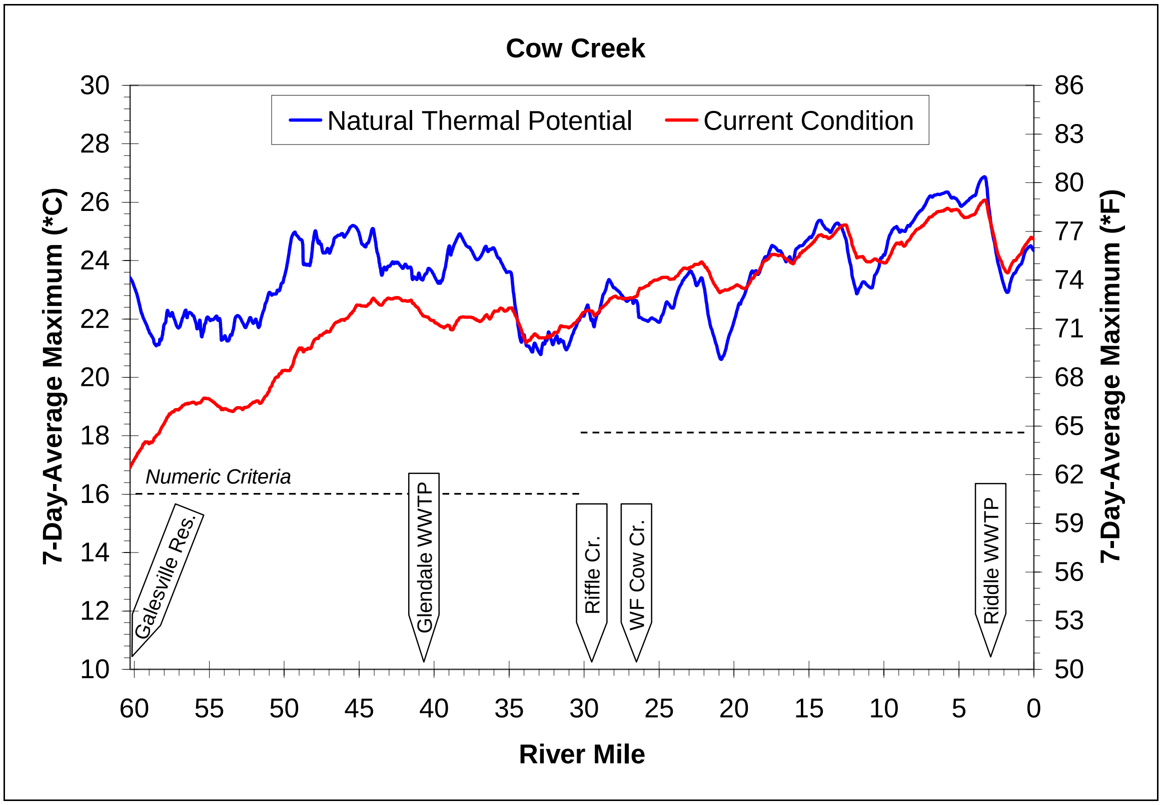


Figure 3.20 **Cow Creek temperature simulation results.**

3.7.3 Olalla-Lookingglass Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Olalla-Lookingglass Creek.

This simulation began a few miles upstream of where Berry Creek enters Olalla Creek. Berry Creek's flows are augmented by cool reservoir withdrawals, resulting in about a 12°C reduction in temperature under the current conditions (at approximately river mile 19). The natural thermal potential simulation assumes that the reservoir does not exist, and uses "natural" flows and temperature inputs for Berry Creek. The result is that the natural thermal potential of Olalla-Lookingglass Creek is warmer than the current stream temperature in many reaches.

The natural thermal potential temperature exceeds the numeric criteria (18°C). Since the NTP is warmer than the numeric criterion, it becomes the new criteria. Additionally, since the current condition is cooler than the NTP in several stream reaches, there may be assimilative capacity available.

Anthropogenic sources could potentially increase stream temperatures in reaches where the current condition is cooler than the NTP as long as…

- the NTP is not exceeded at any time at any location,
- downstream reaches that are currently below the NTP are not caused to exceed the NTP,
- downstream reaches that are currently warmer than the NTP do not increase more than the allocated human use allowance of 0.1°C, and
- there are no threatened or endangered salmonids.

Natural thermal potential was not modeled during the salmon and steelhead fish use period. Patterns and conclusions from the summer period may not hold during spawning period as Berry Creek Reservoir significantly influences temperature on Ollalla-Lookingglass Creek.

The nonpoint source load allocation consists of a portion of the assimilative capacity plus 0.1°C human use allowance. (Assimilative capacity may be shared with point sources.)

Coho salmon are proposed to be listed as a "threatened" under the Endangered Species Act by the National Marine Fisheries Service (NMFS). In the event that Coho salmon are officially listed as threatened, the cold water protection narrative portion of Oregon's stream temperature standard will be invoked. It reads, "*waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present*". (OAR Chapter 340, Division 41)

The assimilative capacity (and load allocation) of Olalla and Lookingglass Creeks is not quantified within this TMDL. The amount of solar heat load required to increase temperatures up to the NTP is variable both temporally and spatially. For example, a specific heat load may cause a 1 degree increase at one location, but the same heat load may cause a 2 degree increase at different location. In addition, different seasons and different flow regimes will affect the amount of heat necessary to increase stream temperatures.

Flow volume may also be considered a "source" of temperature increases. For example, if releases from Berry Creek Reservoir were reduced by 50% during the simulation period, stream temperatures would be warmer. Such a scenario would effectively be using a portion of the available assimilative capacity.

TMDL implementation must ensure that all anthropogenic sources (those influencing flow and those influencing effective shade) do not cumulatively cause violations of the applicable criteria anywhere along

Olalla and Lookingglass Creeks or in other downstream reaches within the Umpqua River Basin stream network.

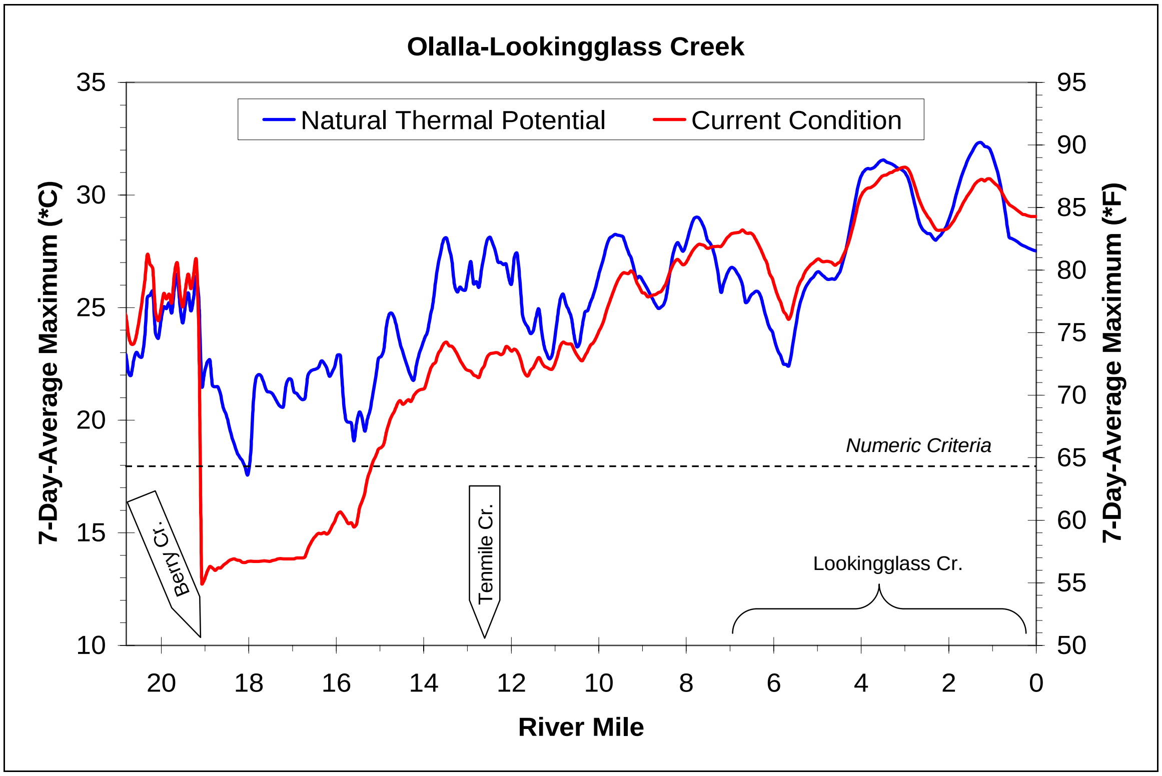


Figure 3.21 **Olalla-Lookingglass Creek temperature simulation results.**

3.7.4 South Umpqua River

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for the South Umpqua River.

The South Umpqua River is wide and existing riparian shade is almost at potential shade (Figure 3.12). These features contribute to the fact that the current stream temperatures are close to the natural thermal potential of the river. The key factor is that the South Umpqua River is wide, resulting in low current and potential effective shade levels.

Current floodplain connectivity, large woody debris, channel complexity, and other factors may differ from what is natural for the South Umpqua River, resulting in warmer current stream temperatures. However, contemporary scientific knowledge does not provide data which supports manipulating those factors in a natural thermal potential modeling scenario. Such limitations of stream temperature modeling should be kept in mind, and the natural thermal potential simulated herein has potential errors associated with it.

The natural thermal potential simulation results from Jackson, Cow, and Olalla-Lookingglass Creeks were used as inputs to the South Umpqua River simulations. Slight differences between the current stream temperatures and the natural thermal potential stream temperatures can be seen below river mile 81, where Jackson Creek enters. The other tributaries and point sources had insignificant impacts on the South Umpqua River natural thermal potential stream temperature.

The natural thermal potential temperature exceeds the numeric criteria (16°C and 18°C) so there is no assimilative capacity for the South Umpqua River. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

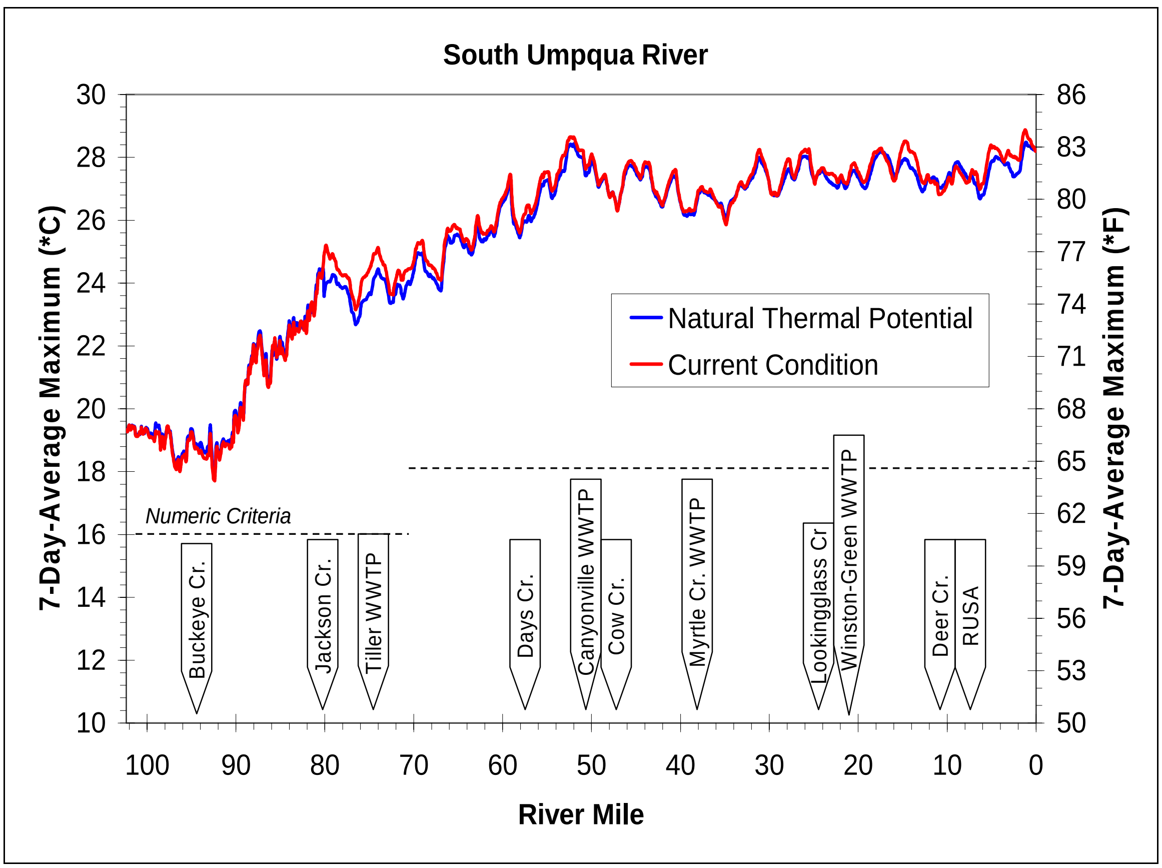


Figure 3.22 **South Umpqua River temperature simulation results.**

3.7.5 Lake Creek

Heat Source simulations were performed for July 8-11, 2001 from Lake Creek's mouth at Lemolo Reservoir to its headwaters at Diamond Lake. These temperatures represent the summertime critical period for Lake Creek. Notice that this chart presents the daily maximum temperature, as opposed to the 7-day average maximum temperature. Limited data availability restricted Heat Source simulations to 4 days during the critical period.

Lake Creek was simulated from Diamond Lake to the mouth. The temperature profile of this stream is unique since it cools as it approaches the mouth. The water in Diamond Lake naturally absorbs solar energy, setting the upper boundary of Lake Creek at warmer temperatures than a comparable stream which originates from groundwater or snow melt. A network of wetlands and springs contributes cooler water to Lake Creek. Those cool water contributions, combined with riparian shading moderate Lake Creek temperatures as it flows toward its mouth.

The natural thermal potential temperature exceeds the numeric criterion (18°C) and there is no assimilative capacity for Lake Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

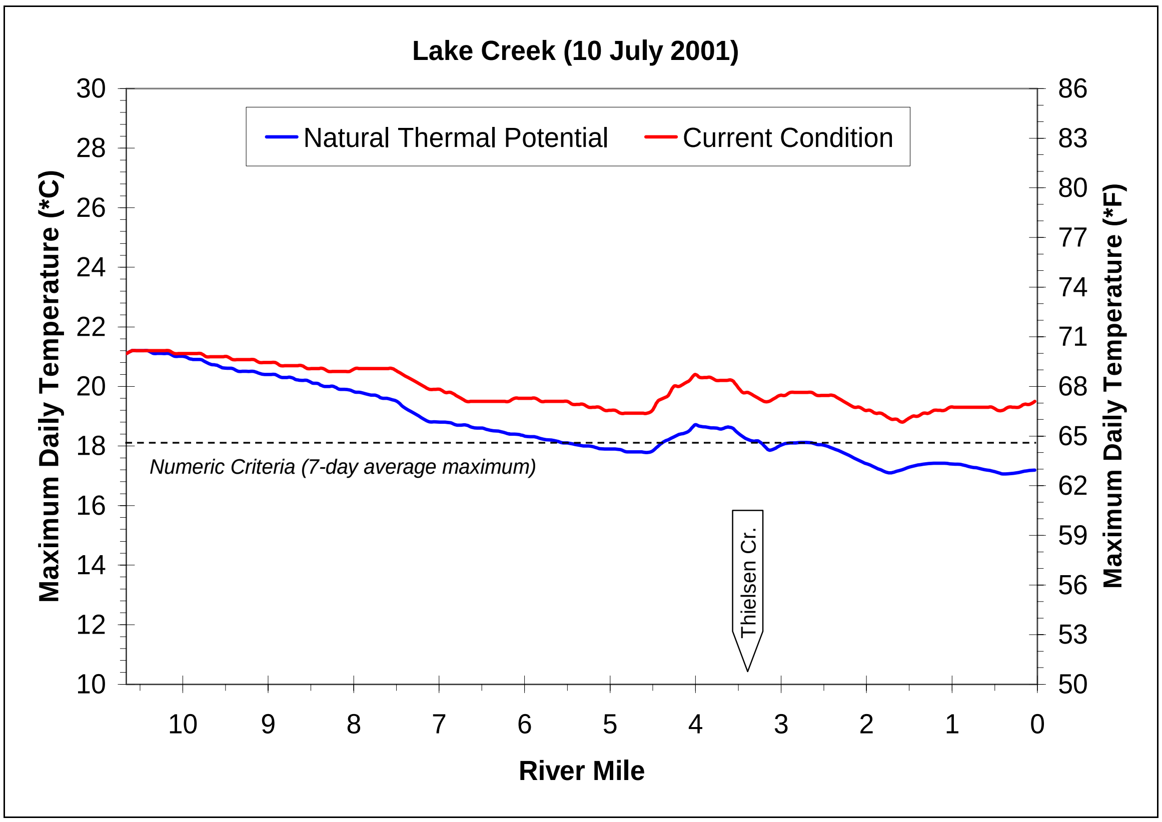


Figure 3.23 **Lake Creek temperature simulation results.**

3.7.6 Clearwater River

Heat Source simulations were performed for July 8-11, 2001. These temperatures represent the summertime critical period for Clearwater River. Notice that this chart presents the daily maximum temperature, as opposed to the 7-day average maximum temperature. Limited data availability restricted Heat Source simulations to 4 days during the critical period.

The Clearwater River simulation begins at Stump Lake (near river mile 8.1). Since the natural thermal potential scenario has more instream flow than the current condition, there is less variability in the temperature profile. Powerhouse #1 is located near river mile 5, where the current temperature drops approximately 5°C. This temperature decrease is a result of previously diverted water coming back to the Clearwater River through Powerhouse #1.

The green line in the chart below represents the natural thermal potential scenario with the 401 Certification minimum bypass reach flows, instead of the "natural flows" (the NTP and 401 Cert. temperatures are the same between until river mile 5). The scenario temperatures diverge at Powerhouse #1 because the 401 certification simulation includes previously diverted water returning to the bypass reach via the powerhouse. The 401 certification simulation uses the *current condition* water temperatures at Powerhouse #1, since diversion canals were not simulated and potential temperatures for various withdrawal scenarios are not available. It is possible that implementing the 401 Certification minimum flows may result in different water temperatures flowing through Powerhouse #1.

Natural flows during the simulation period were less than the 401 certification minimum bypass reach flows, but that difference did not measurably affect stream temperatures. See the **Umpqua River Basin Temperature TMDL Appendix** for the flow profile.

The Clearwater River is not on the 303(d) list for temperature. The natural thermal potential temperature is below the numeric criterion (18°C) and there is assimilative capacity for the Clearwater River. Assimilative capacity is based on the difference between the natural thermal potential temperatures and the numeric criterion.

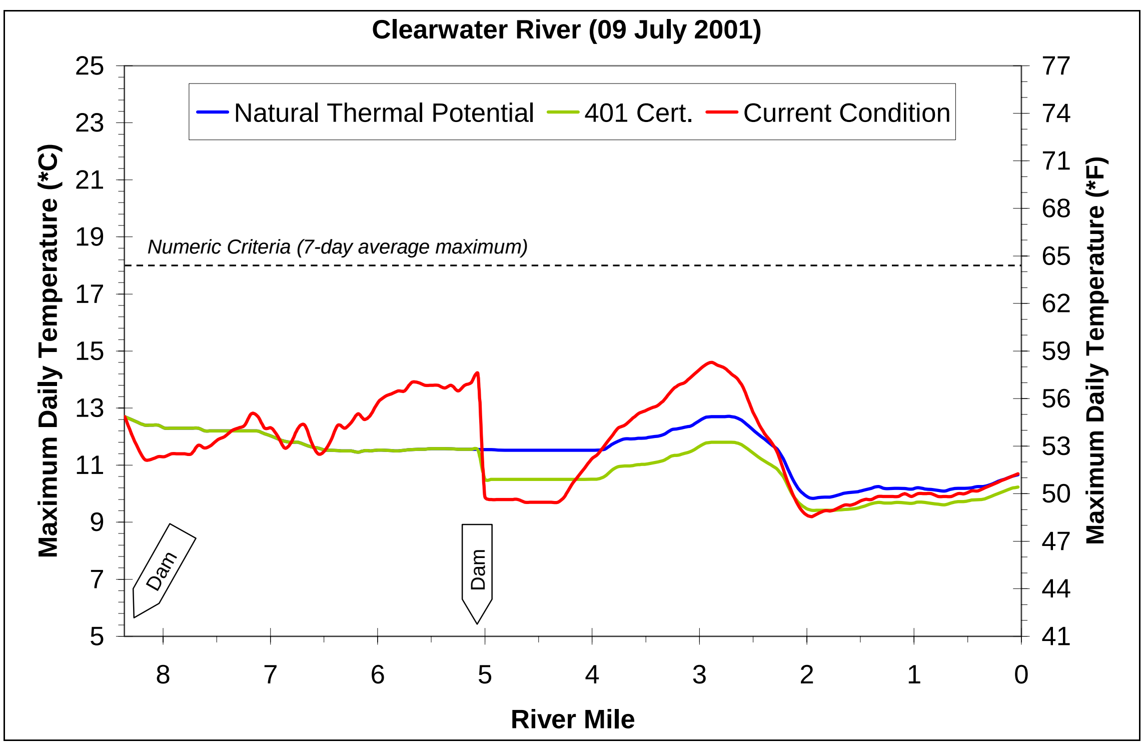


Figure 3.24 **Clearwater River temperature simulation results.**

3.7.7 Fish Creek

Heat Source simulations were performed for July 8-11, 2001. These temperatures represent the summertime critical period for Fish Creek. Notice that this chart presents the daily maximum temperature, as opposed to the 7-day average maximum temperature. Limited data availability restricted Heat Source simulations to 4 days during the critical period.

The Fish Creek simulation begins just upstream of Clear Creek because of the availability of data. There is a diversion dam at river mile 7. The natural thermal potential temperature profile indicates that the stream remains cooler below the diversion dam.

The 401 Certification bypass reach minimum flows were included in the natural thermal potential scenario (in place of the "natural flows"). During the simulation period, Fish Creek's natural flow was less than the 401 Certification minimum flows. Since there is no storage reservoir, it would have been impossible to meet the 401 Certification minimum flows during the simulation period.

The average July low flow at Big Creek Ranger Station at approximately river mile 7.6 from 1947 to 1965 was 145 cubic feet per second (USGS gage data). Given this information, the 401 Certification minimum flows (40 cfs) may cause temperatures to exceed the natural thermal potential during times when the July natural flow is above 40 cfs. As a measure of TMDL compliance, the 401 Certification minimum bypass reach flows may not violate the applicable criterion in Fish Creek which is 18^{o}C.

The natural thermal potential temperature is slightly below the numeric criterion (18^{o}C) and there is assimilative capacity for Fish Creek. To ensure standard attainment in the North Umpqua River, the available heat load capacity is allocated to PacifiCorp, in the form of their 401 certification. Assimilative capacity is based on the difference between the natural thermal potential temperatures and the numeric criterion.

The measured flows during the simulation period were less than the 401 certification minimum bypass reach flow of 40 cfs. In order to simulate the creek's temperatures under the 401 certification minimum bypass reach conditions, flow volumes upstream of the project reaches were artificially increased in order to provide the necessary minimum flows. Therefore, the 401 certification temperatures shown in Figure 3.26 are slightly cooler than the natural thermal potential temperatures for that simulation period.

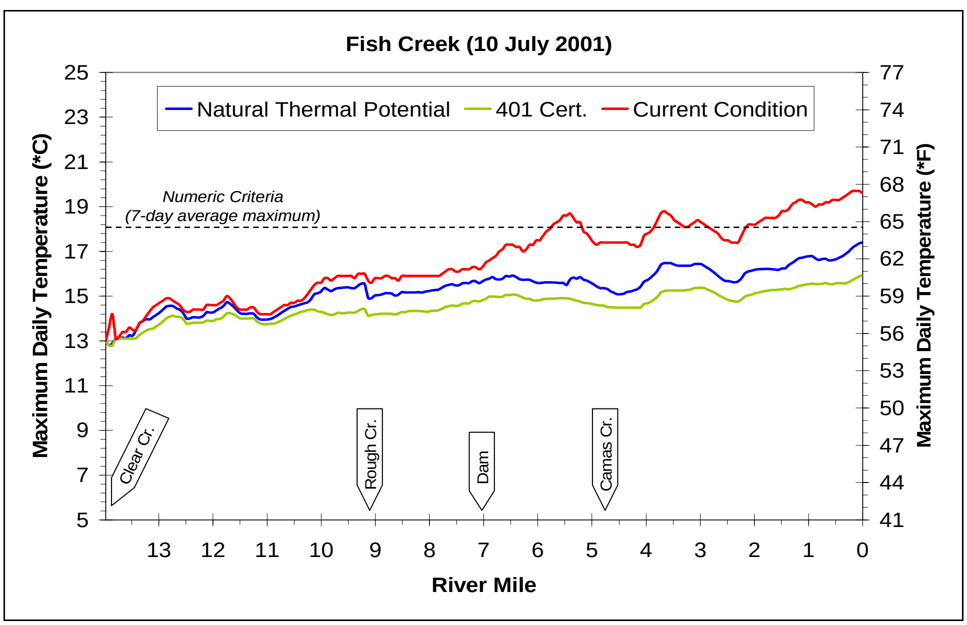


Figure 3.25 **Fish Creek temperature simulation results.**

3.7.8 North Umpqua River (Lemolo Reservoir to Steamboat Creek)

Heat Source simulations were performed for July 8-11, 2001. These temperatures represent the summertime critical period for the upper North Umpqua River. Notice that this chart presents the daily maximum temperature, as opposed to the 7-day average maximum temperature. Limited data availability restricted Heat Source simulations to 4 days during the critical period.

This simulation consists of five separate Heat Source models, separated by each reservoir or diversion dam. Since Heat Source is a one-dimensional model, the reservoirs or backwater behind the dams were not simulated. For the current conditions, measured flows and temperatures below each dam were used as the boundary condition for the downstream simulation. For the natural thermal potential, the flow and temperature output from the upstream model was used as the new boundary condition for the next one downstream. When the five natural thermal potential simulation results are plotted in sequence it is as if the North Umpqua River were free-flowing without dams.

Between Lemolo Reservoir and Lemolo Powerhouse #1, the natural thermal potential is up to 4^{o}C cooler than the current condition. Under the current condition, approximately 30 cfs of cool water is released from Lemolo Reservoir into the bypass reach, and it rapidly heats. Under the natural thermal potential, approximately 300 cfs of water is flowing in the North Umpqua within the reach below Lake Creek. Much of the natural flow volume originates for springs in the vicinity of Lemolo Reservoir, and is naturally cold.

Between Lemolo Powerhouse #1 and Toketee Reservoir, the current condition temperatures continue to increase. The natural thermal potential of this reach remains around 9^{o}C. The sudden decrease in current condition temperature at about river mile 80 is caused by Loafer Creek.

From Toketee Reservoir to Slide Powerhouse, current stream temperatures fluctuate between 12^{o}C and 15^{o}C, and current flows are approximately 30 cfs. Under the natural thermal potential conditions, stream flow is more than 20 times greater and the stream temperatures are consistently around 9^{o}C.

Between the Slide Powerhouse and Soda Springs Reservoir, current stream temperatures climb another 2^{o}C. The natural thermal potential temperatures within this reach remain around 9^{o}C.

The wild and scenic portion of the North Umpqua River extends from Soda Springs Reservoir to Steamboat Creek. Under the current conditions, this reach contains its natural flow volume, since all PacifiCorp diversions have been returned to the river. The cooler natural thermal potential temperatures from upstream reaches influence this reach. Gradual longitudinal heating occurs, and eventually the current condition and the natural thermal potential temperatures converge.

The 401 Certification minimum bypass reach flows were also simulated (green line). This simulation had all the same inputs as the natural thermal potential simulation, except the “natural” flow was replaced with the bypass reach flows and diversions and dams remained in place. The 401 Certification flows result in stream temperatures well above the natural thermal potential. This is mainly due to the fact that the “natural” flows are hundreds of cubic feet per second more than the 401 Certification flows.

Currently, the hydroelectric project measurably increases stream temperatures throughout the entire North Umpqua River and even into the mainstem Umpqua River. Comparing the natural thermal potential and the current stream temperatures in those rivers reveals that the hydroelectric project temperature effects are carried far down stream.

When the 401 Certification minimum flows are implemented, the stream temperatures between Lemolo Reservoir and Steamboat Creek are estimated to not exceed the numeric criteria. In addition, the North Umpqua River would meet the natural thermal potential from Steamboat Creek all the way to the Umpqua River tidewater. These conditions would meet the applicable core cold-water habitat stream temperature criteria (16^{o}C) downstream of Soda Springs and the natural thermal potential below Steamboat Creek. If temperatures between Lemolo and Soda Springs were warmer than those produced by the 401 Certification flows, violations of the standard would likely occur in downstream reaches.

Upstream of Soda Springs, the numeric criterion is 18°C. Downstream of Soda Springs the numeric criterion is 16°C. The natural thermal potential temperature is below the numeric criterion (18°C) upstream of Soda Springs (approximately river mile 69) and there is no salmon use in those reaches so there is assimilative heat load capacity. Heat load above background is allocated to the hydroelectric project, as long as the numeric criterion is not exceeded anywhere within the reaches above Soda Springs and as long as either the numeric criterion is not exceeded or there is no measurable increase in stream temperature (0.3°C) downstream of Soda Springs. The heat load allocation assigned to Pacificorp hydro project bypass reaches is equivalent to implementation of their 401 Certification minimum bypass reach flows.

Assimilative capacity may also be shared with other nonpoint source load allocations, as long as the applicable criteria are met throughout the stream network. Natural disturbance is considered a background source.

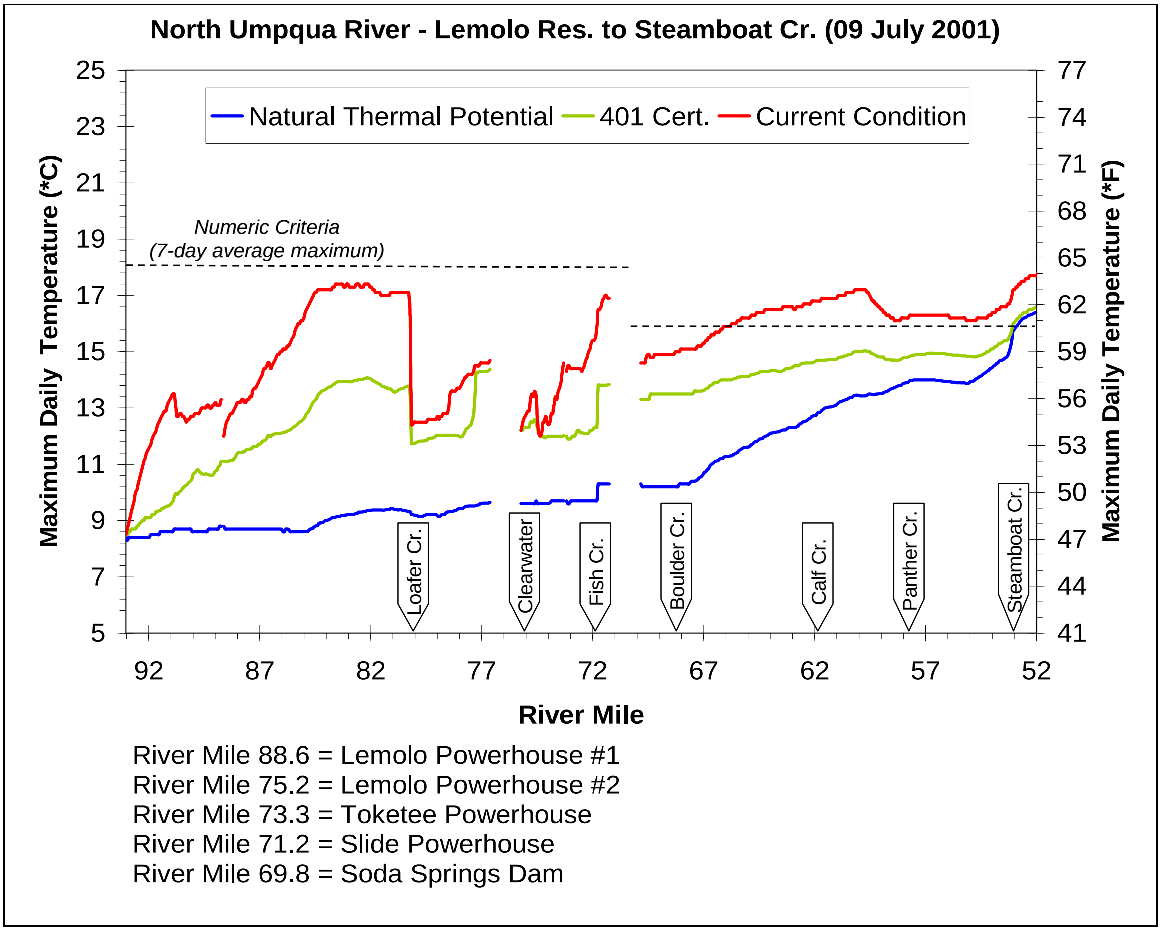


Figure 3.26 **North Umpqua River (Lemolo Res to Steamboat Cr) temperature simulation results.**

3.7.9 Canton Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Canton Creek.

Canton Creek is mostly forested. The natural thermal potential is approximately 1-2^{o}C cooler than the current condition. The Canton Creek simulation output is used as input to the Steamboat Creek simulation.

Immature vegetation is the primary cause of the temperature difference between the current condition and the natural thermal potential along many stream reaches.

The natural thermal potential temperature exceeds the numeric criterion (16^{o}C) so there is no assimilative capacity for Canton Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

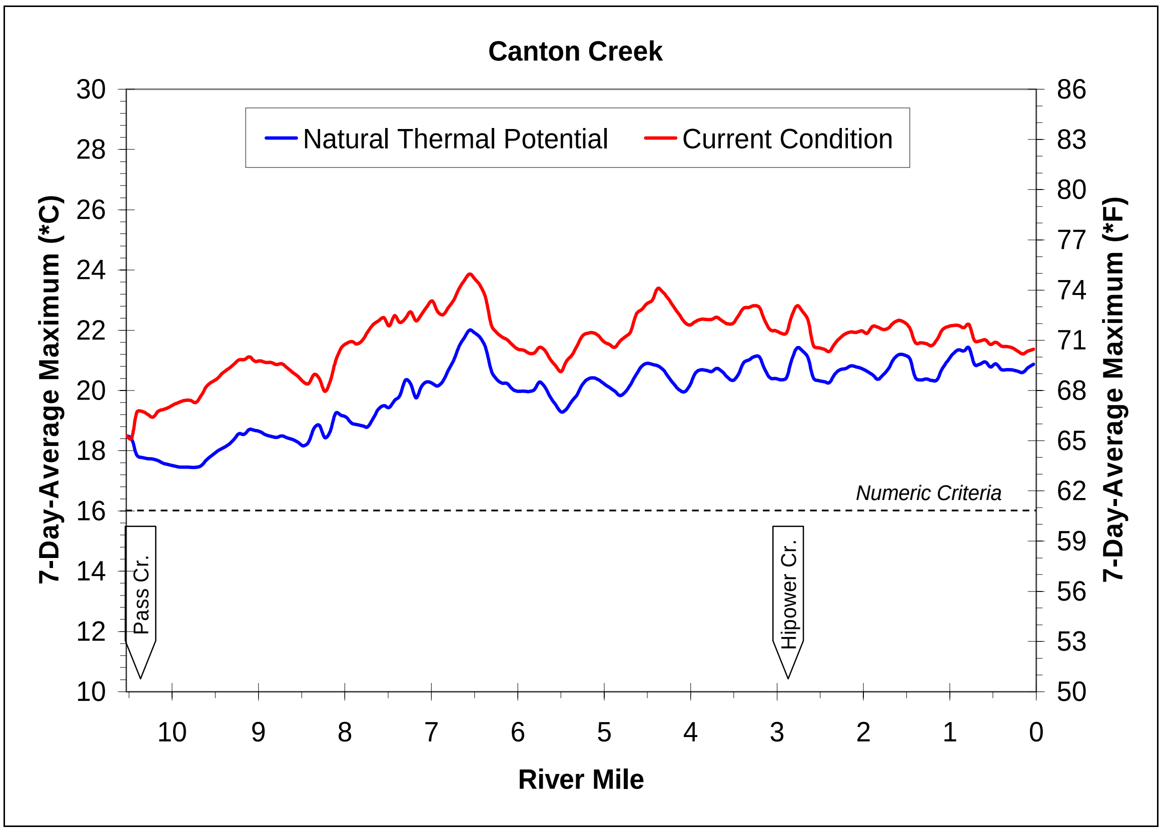


Figure 3.27 **Canton Creek temperature simulation results.**

3.7.10 Steamboat Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Steamboat Creek.

Steamboat Creek from river mile 7 to 13 is currently at or near the natural thermal potential. From river mile 7 to the mouth and river mile 19 to 13, the natural thermal potential is slightly cooler than the current condition. These cooler temperatures are a result of increased shade levels in the natural thermal potential scenario.

In the lower portion of the stream, the difference between the current condition and the natural thermal potential stream temperatures can be attributed primarily to the fact that the existing vegetation is immature along some stream reaches. In the upper reaches, the difference can be attributed to decreased tributary temperatures.

The natural thermal potential temperature exceeds the numeric criterion (16°C) so there is no assimilative capacity for Steamboat Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

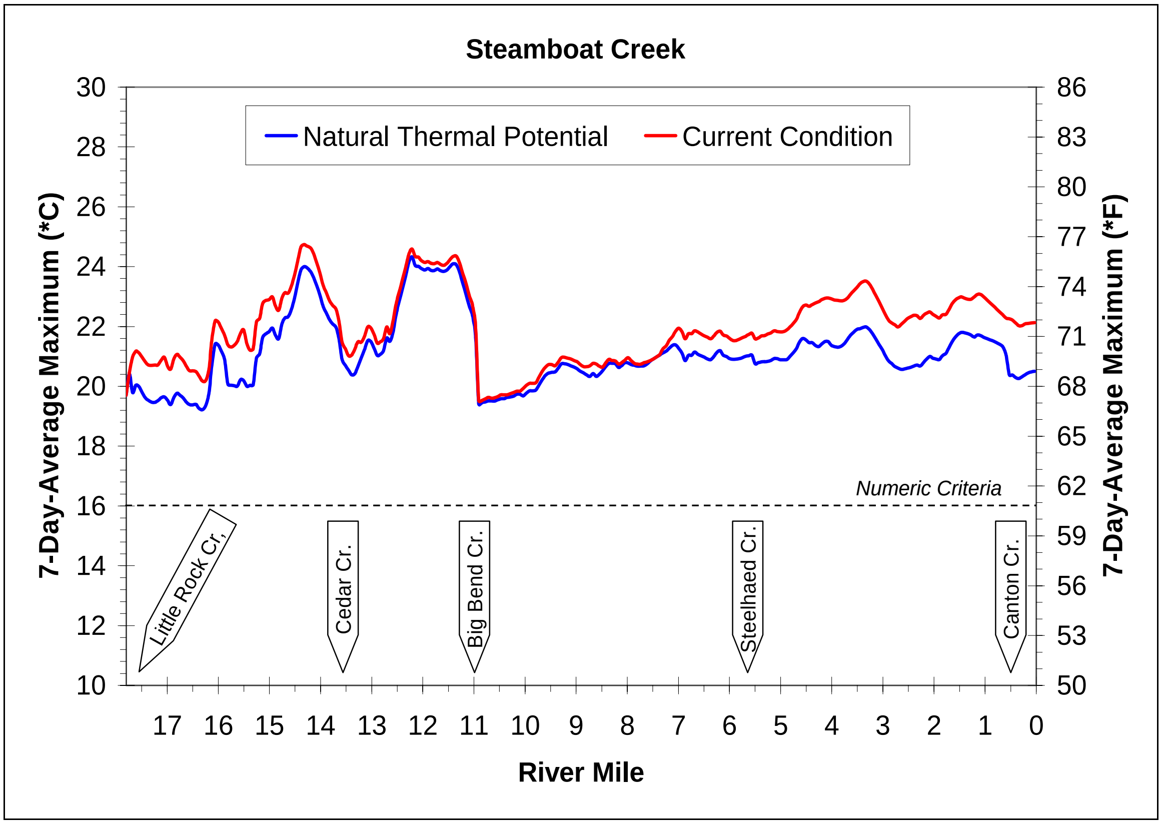


Figure 3.28 **Steamboat Creek temperature simulation results.**

3.7.11 Rock Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Rock Creek.

Timber harvest activities have occurred in the Rock Creek Watershed, creating patches of differently aged vegetation and lowered effective shade (Figure 3.12). The natural thermal potential is cooler than the current condition, primarily due to effective shade reductions. It is interesting to note that the lower reaches of Rock Creek simulation indicate smaller differences between current and natural thermal potential temperatures. The lower 7 miles are well-vegetated by mature trees so there is little difference between the current and potential effective shade.

The difference between the current condition and the natural thermal potential stream temperatures can be attributed primarily to the fact that the existing vegetation is immature along many stream reaches, particularly within the upper 7 stream miles. In addition, there is a road near the stream in the upper reaches.

The natural thermal potential temperature exceeds the numeric criterion (16^{o}C) so there is no assimilative capacity for Rock Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

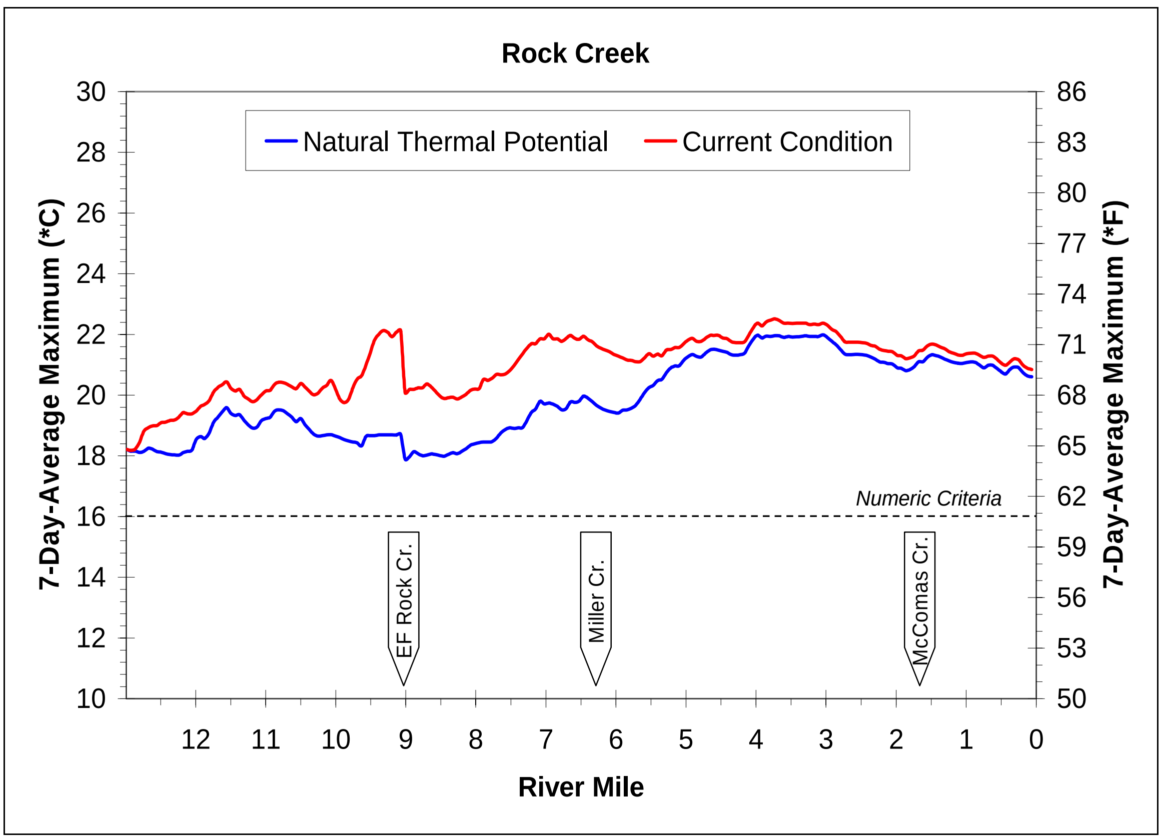


Figure 3.29 **Rock Creek temperature simulation results.**

3.7.12 Cavitt Creek

The following is presented as supplemental information to the Umpqua River Basin TMDL and the Little River Watershed TMDL (ODEQ, 2001, approved by EPA in 2002) which contains allocations for Cavitt Creek. Cavitt Creek was simulated as part of the Umpqua River Basin TMDL analysis in order to account for its thermal effects on downstream receiving waters. Simulation dates differ between the Little River Watershed TMDL and this analysis; however, the NTP results are very similar.

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Cavitt Creek.

The Cavitt Creek watershed has experienced timber harvest activities. As a result, the current temperatures are warmer than the natural thermal potential of the stream.

The difference between the current condition and the natural thermal potential stream temperatures can be attributed primarily to the fact that the existing vegetation is immature along many stream reaches.

The natural thermal potential temperature exceeds the numeric criterion (16^{o}C) so there is no assimilative capacity for Cavitt Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

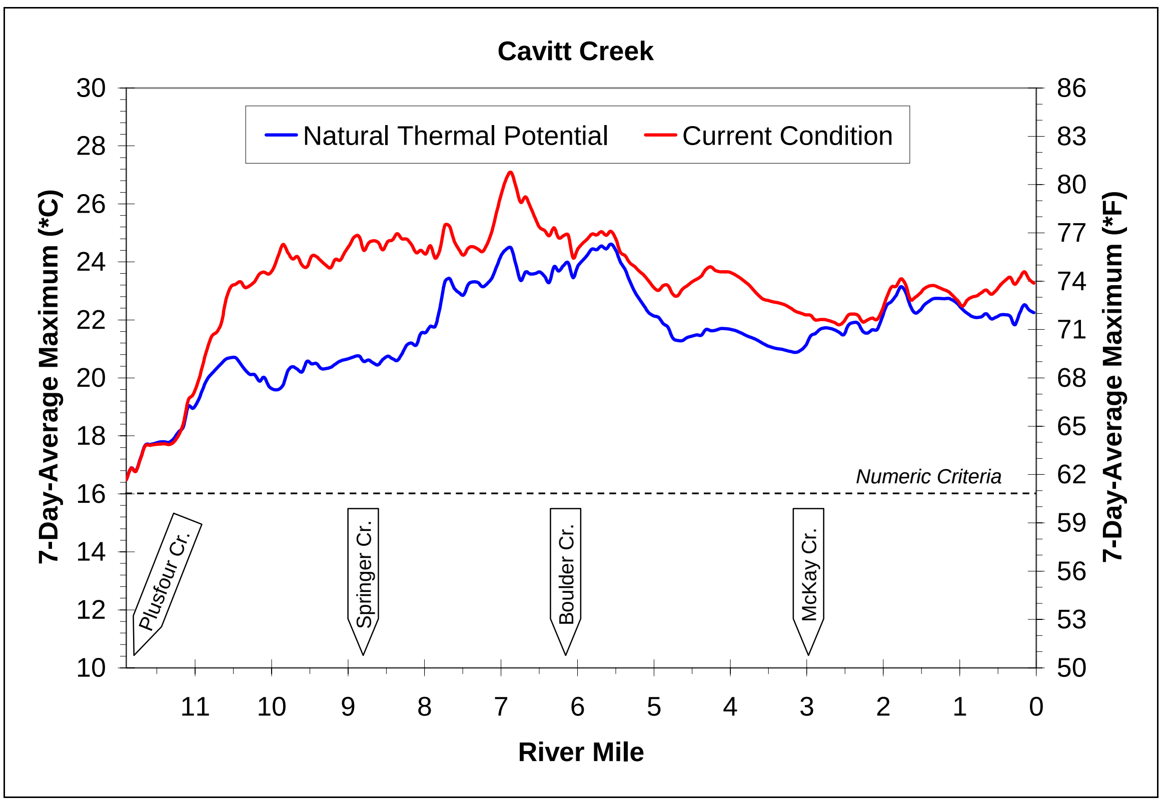


Figure 3.30 **Cavitt Creek temperature simulation results.**

3.7.13 Little River

The following is presented as supplemental information to the Umpqua River Basin TMDL and the Little River Watershed TMDL (ODEQ, 2001, approved by EPA in 2002) which contains allocations for Little River. Little River was simulated as part of the Umpqua River Basin TMDL analysis in order to account for its thermal effects on downstream receiving waters. Simulation dates differ between the Little River Watershed TMDL and this analysis; however, the NTP results are very similar.

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Little River.

Like Cavitt Creek, the Little River Watershed hosts timber harvest activities. For most of the stream, the natural thermal potential is cooler than the current condition. Heating rates are reduced in many small reaches under the natural thermal potential scenario, as a result of higher effective shade. Theses reductions moderate the temperatures of Little River.

The difference between the current condition and the natural thermal potential stream temperatures can be attributed primarily to the fact that the existing vegetation is immature along many stream reaches.

The natural thermal potential temperature exceeds the numeric criterion (16^{o}C) so there is no assimilative capacity for Little River. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

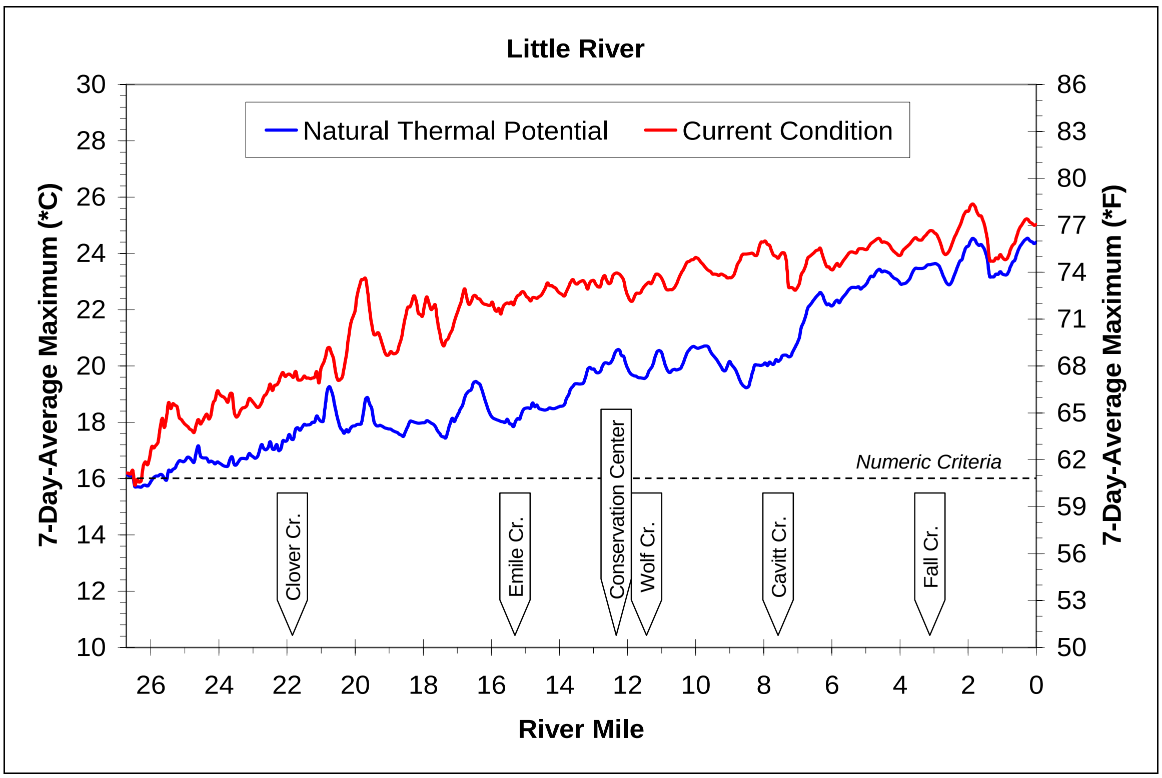


Figure 3.31 **Little River temperature simulation results.**

3.7.14 North Umpqua River (Steamboat Creek to the Mouth)

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for the North Umpqua River.

The North Umpqua River from Steamboat Creek to the mouth has a flow rate greater than 600 cfs and is well vegetated. The North Umpqua hydroelectric project impacts stream temperatures and thus, the current condition is warmer than the natural thermal potential all the way to the mouth. The ample flow volume of the North Umpqua River naturally attenuates heat loss and absorption, so the upstream thermal effects are observed many miles downstream. In general, larger, deeper rivers gain or loose heat less quickly than smaller, shallower streams.

Implementation of the 401 Certification minimum flows would result in summer stream temperatures that meet the natural thermal potential on the North Umpqua River below Steamboat Creek (essentially the same as blue line below). It is undetermined whether the 401 certification minimum flows would result in stream temperatures that meet the applicable temperature criteria during the salmon and steelhead spawning period. This will be addressed in a future TMDL as more data is collected.

In summary, the difference between the current condition and natural thermal potential stream temperatures is primarily due to upstream influences of the hydroelectric project area.

The natural thermal potential temperature exceeds the numeric criterion (16^{o}C) so there is no assimilative capacity for the North Umpqua River below Steamboat Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

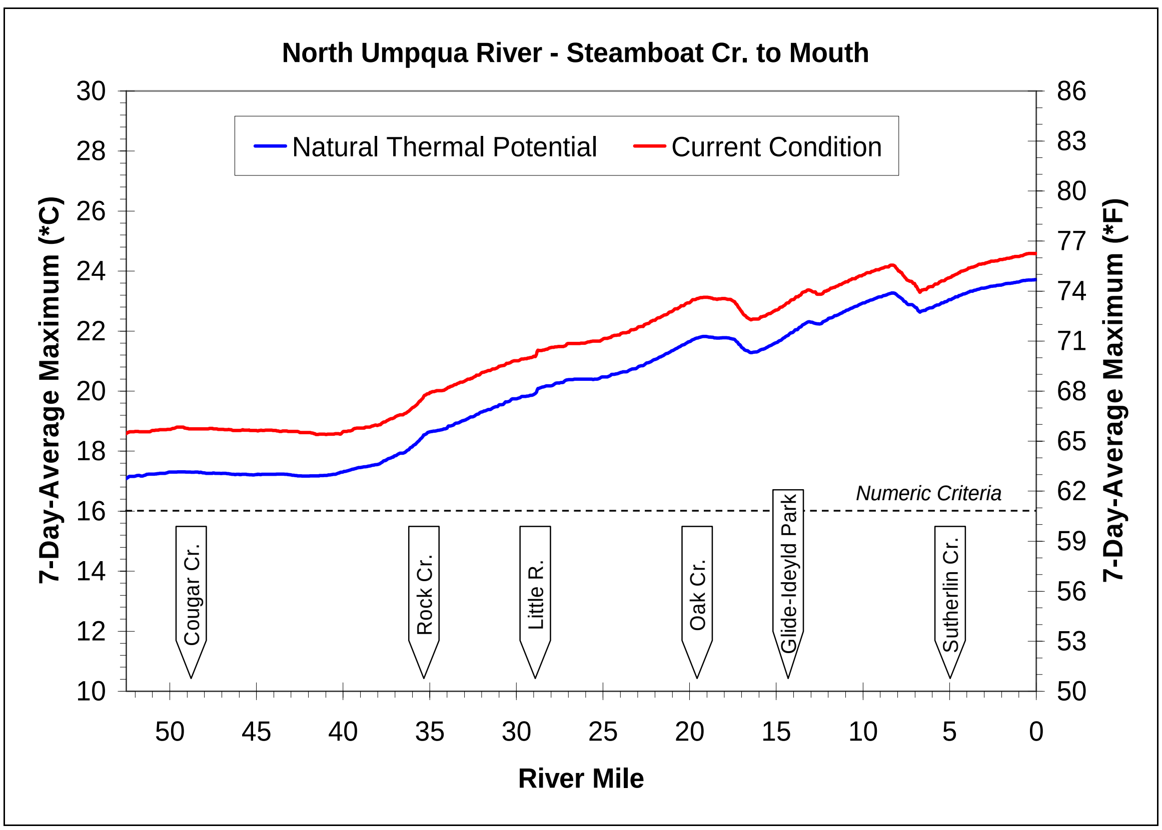


Figure 3.32 **North Umpqua River downstream of Steamboat Creek temperature simulation results.**

3.7.15 Calapooya Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Calapooya Creek.

Calapooya Creek is a low-gradient system. Current condition and natural thermal potential temperatures vary between 26°C and 28°C throughout the lower 20 miles. Localized cooling and heating occurs throughout the reaches, resulting in a highly variable temperature profile. Low stream velocities, pockets of sun and shade, and ground water mixing are some of the possible contributors to the variability in the stream temperature profile.

The natural thermal potential temperature exceeds the numeric criterion (18°C) so there is no assimilative capacity for Calapooya Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

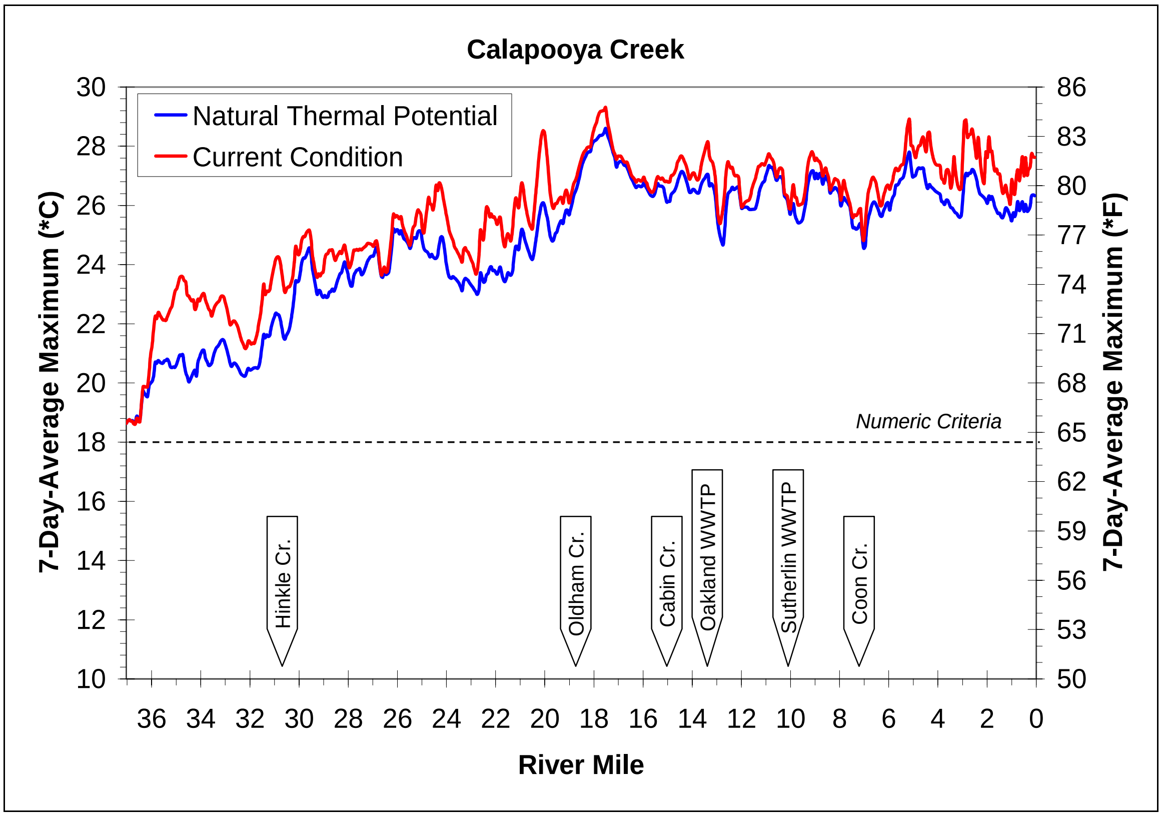


Figure 3.33 **Calapooya Creek temperature simulation results.**

3.7.16 Elk Creek

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for Elk Creek.

Elk Creek is a low-gradient stream. The lower 27 miles of Elk Creek vary between 24^{o}C and 28^{o}C. The current condition and natural thermal potential temperatures are similar in many reaches.

Both Calapooya and Elk Creeks are predominantly surrounded by agricultural lands. The natural thermal potential scenario does not account for floodplain connectivity, large woody debris, channel complexity, and other factors that may be degraded due to settlement and development. Therefore, simulated natural thermal potential temperatures have a non-quantifiable uncertainty associated with them. There was not enough information available to estimate natural flows, so natural thermal potential was estimated using current flow.

The natural thermal potential temperature exceeds the numeric criterion (18^{o}C) so there is no assimilative capacity for Elk Creek. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

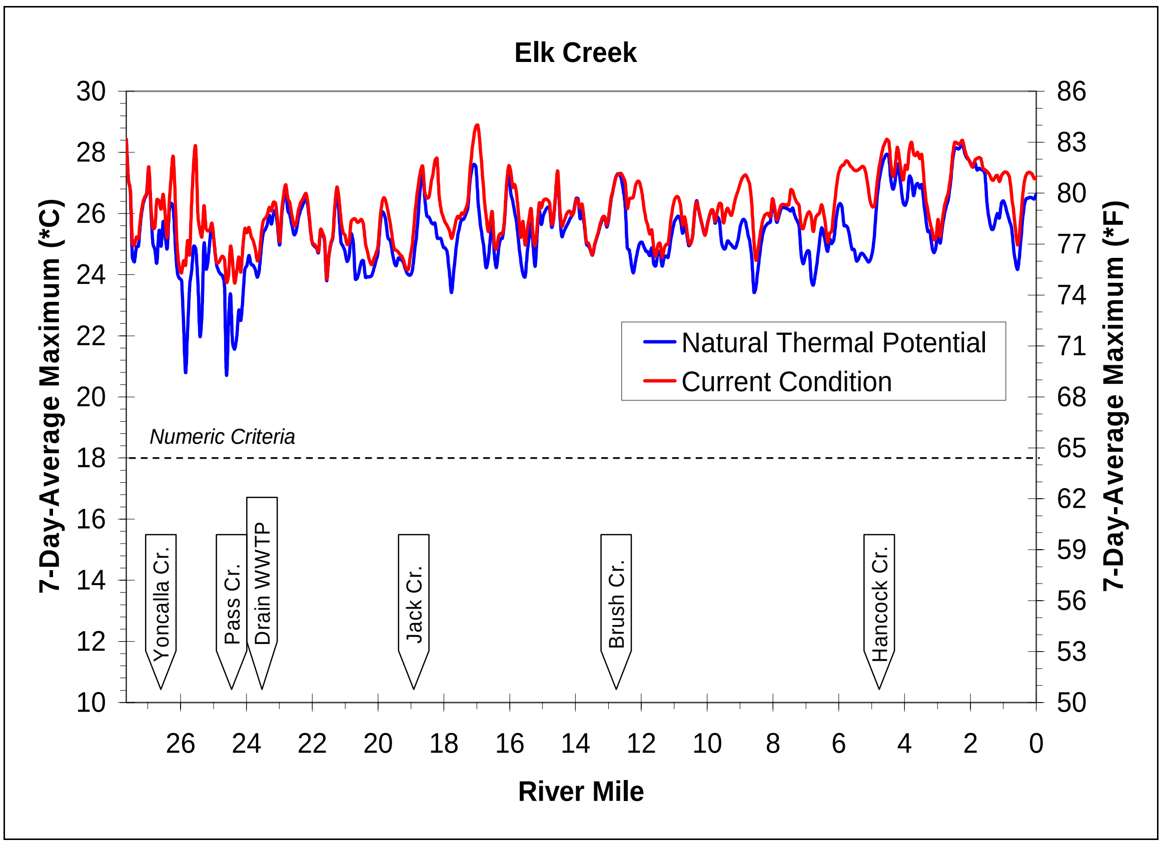


Figure 3.34 **Elk Creek temperature simulation results.**

3.7.17 Umpqua River

Heat Source simulations were performed for July 12-31, 2002. These temperatures represent the summertime critical period for the Umpqua River.

The Umpqua River was simulated from the forks to tidewater (approximately river mile 25). Tidal influences in the lower 25 miles of the Umpqua River are not conducive to Heat Source modeling. The Smith River confluence is within the tidal zone. 7-day average maximum stream temperatures were between 26°C and 27°C. Effective shade on the Umpqua River mainstem is naturally low (usually below 10% effective shade) because the river is large and wide. In addition, the significant flow volume acts to moderate any longitudinal variability in stream temperatures.

The Umpqua River simulation takes into account the cumulative effects of all upstream tributaries that were simulated using Heat Source. The North Umpqua Hydroelectric project creates warmer current condition stream temperatures, which are observed all the way through the North Umpqua River and into the Umpqua River.

Implementation of the 401 Certification minimum flows would result in summer stream temperatures identical to the natural thermal potential shown below. The warmer current condition temperatures are primarily an effect of the hydroelectric project on the upper North Umpqua River.

The natural thermal potential temperature exceeds the numeric criterion (18°C) so there is no assimilative capacity for the Umpqua River. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

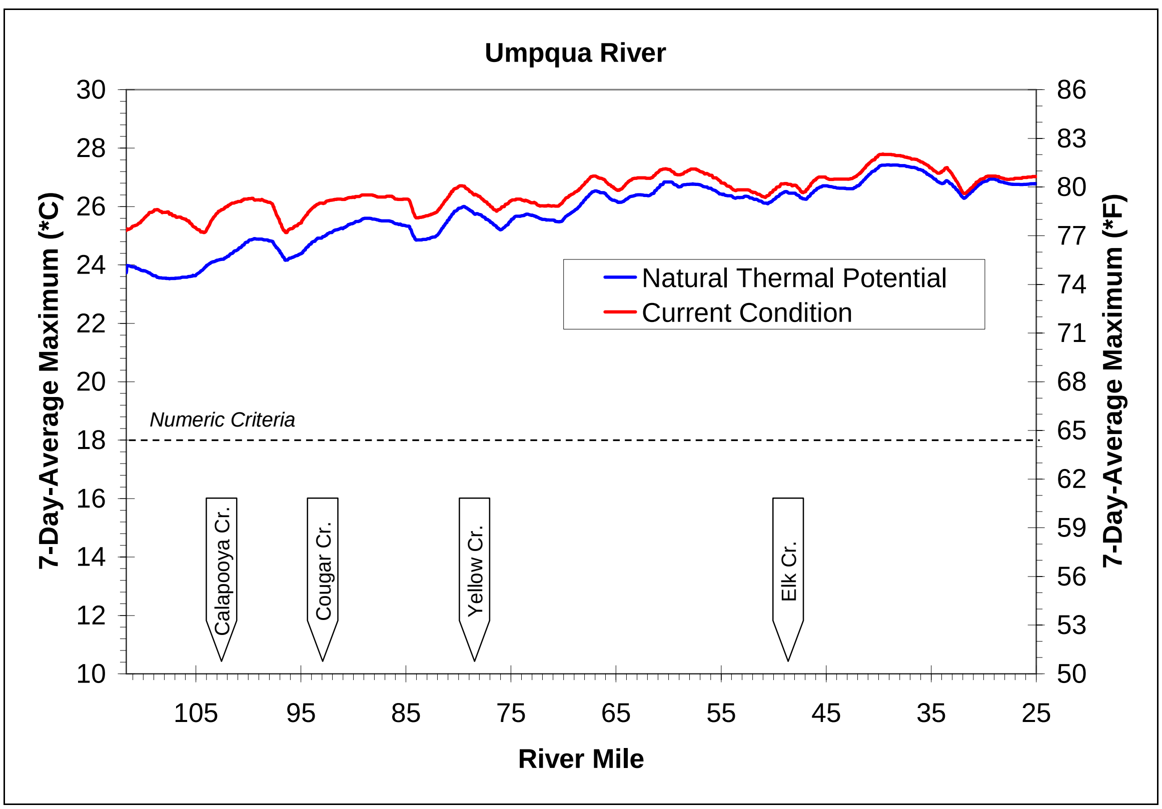


Figure 3.35 **Umpqua River temperature simulation results.**

3.7.18 North Fork Smith River

Heat Source simulations were performed for August 9, 1999, using the earlier version of the Heat Source v. 6.5.1 (the latest version available when the modeling was done). The temperatures on this date represent the summertime critical period for the mainstem Smith River. This version of the model cannot determine a 7-day average maximum, so maximum daily temperatures are reported. This simulation did not incorporate natural disturbance, which is considered a background source.

This simulation began 1.4 miles up on Kentucky Creek, a tributary joining the North Fork Smith at about river mile 26, and continued downstream to about river mile 5.2. Below this point, tidal influences affect the North Fork and this portion was not modeled.

The North Fork Smith River is a relatively high gradient stream, especially in the upper reaches. Forestry dominates the upper portion of the watershed, and agricultural operations are concentrated on the lower end.

The natural thermal potential temperature is below the numeric criteria (18^{o}C). Since the NTP is cooler than the numeric criterion, the numeric criterion is not superceded by it.

Currently there is no assimilative capacity available because the current stream temperatures exceed the numeric criterion. TMDL implementation must focus on reducing anthropogenic heating until the numeric criterion is met in all reaches at all times.

The NTP is simulated assuming that there is no anthropogenic heat load. Successful TMDL implementation will allow anthropogenic heat load on the North Fork Smith River as long as the numeric criterion is not exceeded. Reductions in the current anthropogenic heat load are necessary for the North Fork Smith River to meet the TMDL.

Coho salmon are proposed to be listed as a “threatened” under the Endangered Species Act by the National Marine Fisheries Service (NMFS). In the event that Coho salmon are officially listed as threatened, the cold water protection narrative portion of Oregon’s stream temperature standard will be applicable. It reads “*waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present*”. (OAR Chapter 340, Division 41) This would become a factor when and where the current or ambient temperatures are below the numeric criterion.

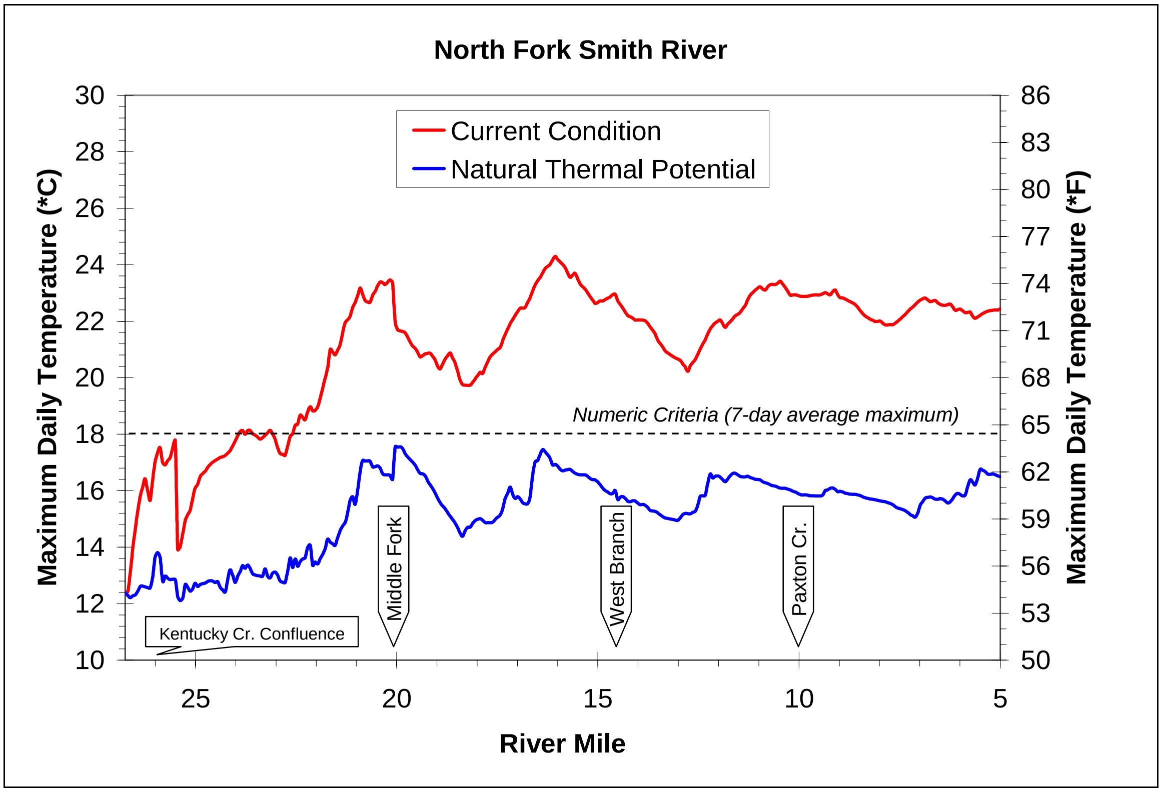


Figure 3.36 North Fork Smith River temperature simulation results for August 9, 1999.

3.7.19 West Fork Smith River

Heat Source simulations were performed for July 16, 2000, using the earlier version of the Heat Source model (6.5.1) that was the latest available when the modeling was done. The temperatures on this date represent the summertime critical period for the mainstem Smith River. This version of the model cannot determine a 7-day average maximum, so maximum daily temperatures are reported. This simulation did not incorporate natural disturbance, which is considered a background source.

The simulation began at about river mile 11.5 and continued downstream to the mouth, where the West Fork Smith River joins the mainstem Smith River. System potential temperatures at the mouth were used as inputs to the system potential simulation of the mainstem Smith River.

The West Fork Smith River drains the steep Coast Range to its west, which also provides significant topographical shade to the stream. Flow measurements suggest contributions of cold groundwater near the lower end. Currently portions of the West Fork is at or below the numeric criterion (18 ^{o}C), but more cooling is still possible.

The natural thermal potential temperature is below the numeric criteria (18^{o}C). Since the NTP is cooler than the numeric criterion, the numeric criterion is <u>not</u> superceded by it.

Currently there is no assimilative capacity available because the current stream temperatures exceed the numeric criterion. TMDL implementation must focus on reducing anthropogenic heating until the numeric criterion is met in all reaches at all times.

The NTP is simulated assuming that there is no anthropogenic heat load. Successful TMDL implementation will allow anthropogenic heat load on the West Fork Smith River as long as the numeric criterion is not exceeded. Reductions in the current anthropogenic heat load are necessary for the West Fork Smith River to meet the TMDL.

Coho salmon are proposed to be listed as a “threatened” under the Endangered Species Act by the National Marine Fisheries Service (NMFS). In the event that Coho salmon are officially listed as threatened, the cold water protection narrative portion of Oregon’s stream temperature standard will be invoked. It reads “*waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present*”. (OAR Chapter 340, Division 41) This would become a factor when and where the current or ambient temperatures are below the numeric criterion.

The assimilative capacity of West Fork Smith River is not quantified within this TMDL. The amount of solar heat load required to increase temperatures up to the NTP is variable both temporally and spatially. For example, a specific heat load may cause a 1 degree increase at one location, but the same heat load may cause a 2 degree increase at different location. In addition, different seasons and different flow regimes will affect the amount of heat necessary to increase stream temperatures.

TMDL implementation must ensure that all anthropogenic sources (those influencing flow and those influencing effective shade) do not cumulatively cause violations of the applicable criteria anywhere along West Fork Smith River or in other downstream reaches within the Umpqua River Basin stream network.

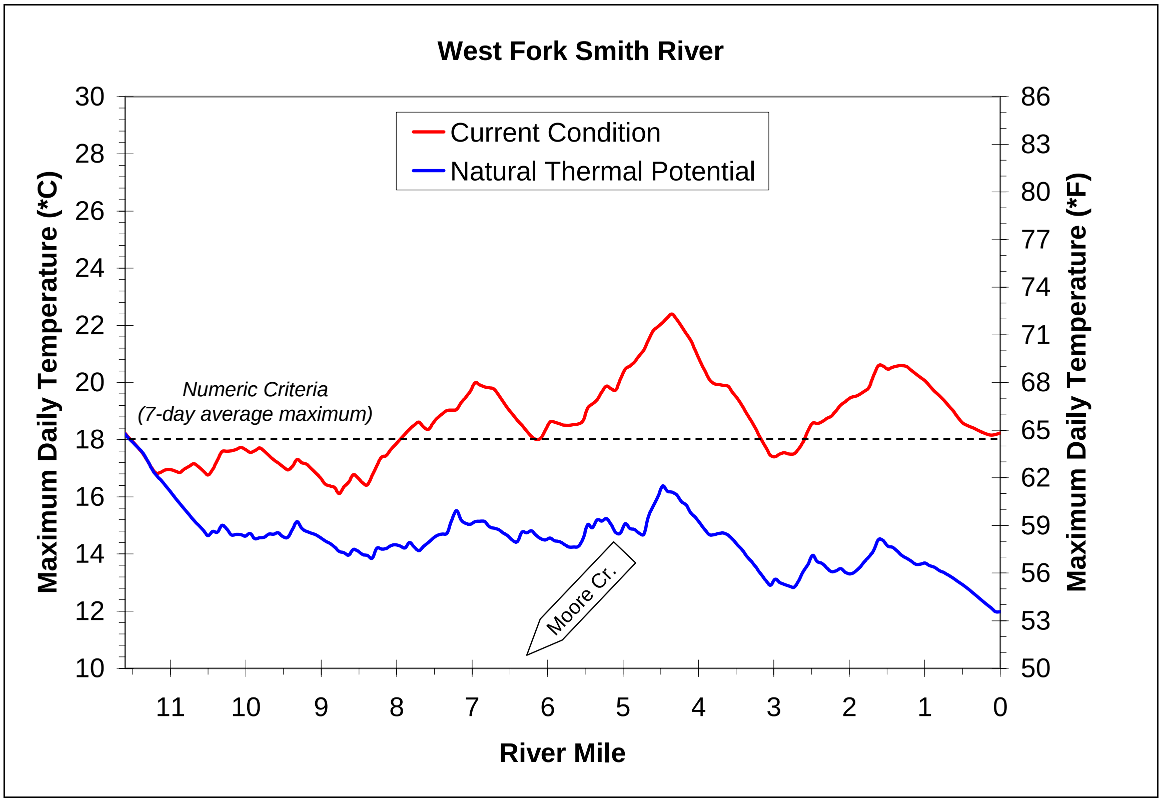


Figure 3.37 **West Fork Smith River temperature simulation results for July 16, 2000.**

3.7.20 Smith River Mainstem

Heat Source simulations were performed for July 16, 2000, using the earlier version of the Heat Source model (6.5.1) that was the latest available when the modeling was done. The temperatures on this date represent the summertime critical period for the mainstem Smith River. This version of the model cannot determine a 7-day average maximum, so maximum daily temperatures are reported. This simulation did not incorporate natural disturbance, which is considered a background source.

This simulation began at the confluence of the Smith River and Peterson Creek at approximately river mile 87, and continued downstream to Johnson Creek at approximately river mile 31. Below Johnson Creek, the mainstem Smith River is tidally influenced and was not modeled. The temperature output from the model of the West Fork Smith River at system potential vegetation was used in the determination of natural thermal potential for the mainstem.

The mainstem Smith River is a relatively low gradient river that drains the entire watershed, much of which is forestland. The lower portion of the mainstem drains agricultural lands. Modeling shows that the mainstem Smith River can be significantly cooled with riparian vegetation.

The natural thermal potential is at or near the numeric criterion (18^{o}C) below the South Fork Smith, but above the criterion starting at about river mile 47. Above the South Fork Smith, current temperatures are below the numeric criterion. Besides the human use allowance, all sources are allocated zero heat loads above background. Natural disturbance is considered a background source.

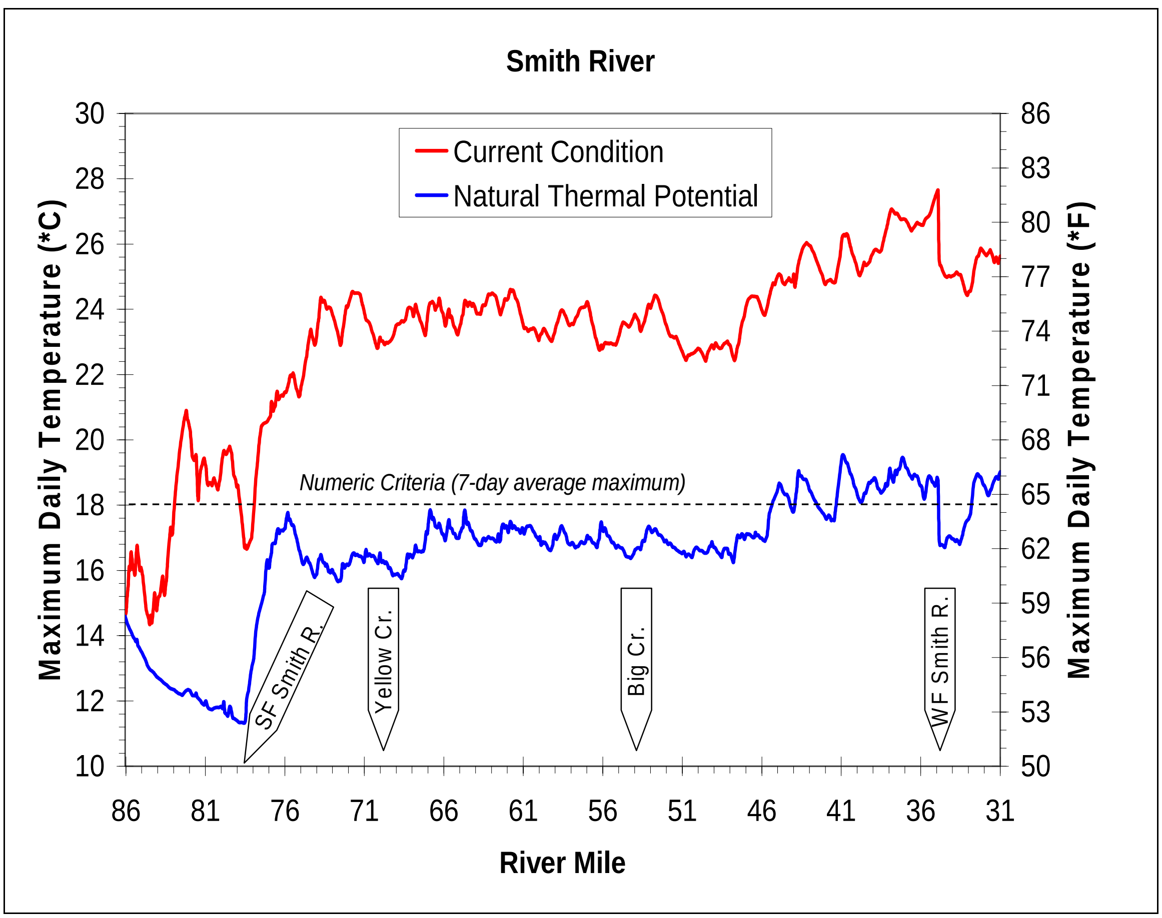


Figure 3.38 **Mainstem Smith River temperature simulation results for July 16, 2000**

3.7.21 Combined Results – North Umpqua River and Umpqua River

Figure 3.40 shows the combined results of the North Umpqua River and Umpqua River simulations. As previously mentioned, outputs of upstream models were used as inputs for downstream models for the NTP and 401 certification scenarios.

Between Lemolo Reservoir and Steamboat Creek, the NTP is cooler than the numeric criteria. Some of the assimilative capacity is assigned to the Pacificorp hydro project. In order to meet their load allocation during the critical summertime period, Pacificorp must implement their 401 certification bypass reach minimum flows.

Implementing the 401 Certification bypass reach minimum flows and other nonpoint source load allocations (i.e., effective shade surrogates) will result in summer stream temperatures that are the same as the NTP, from Steamboat Creek to tidewater on the Umpqua River. In other words, the simulation demonstrated that the 401 Certification bypass reach minimum flows will meet the applicable criteria during the summer both within the hydro project area and everywhere downstream. It is undetermined whether the 401 certification minimum flows would result in stream temperatures that meet the applicable criteria during the salmon and steelhead spawning period. This will be addressed in a future TMDL as more data is collected.

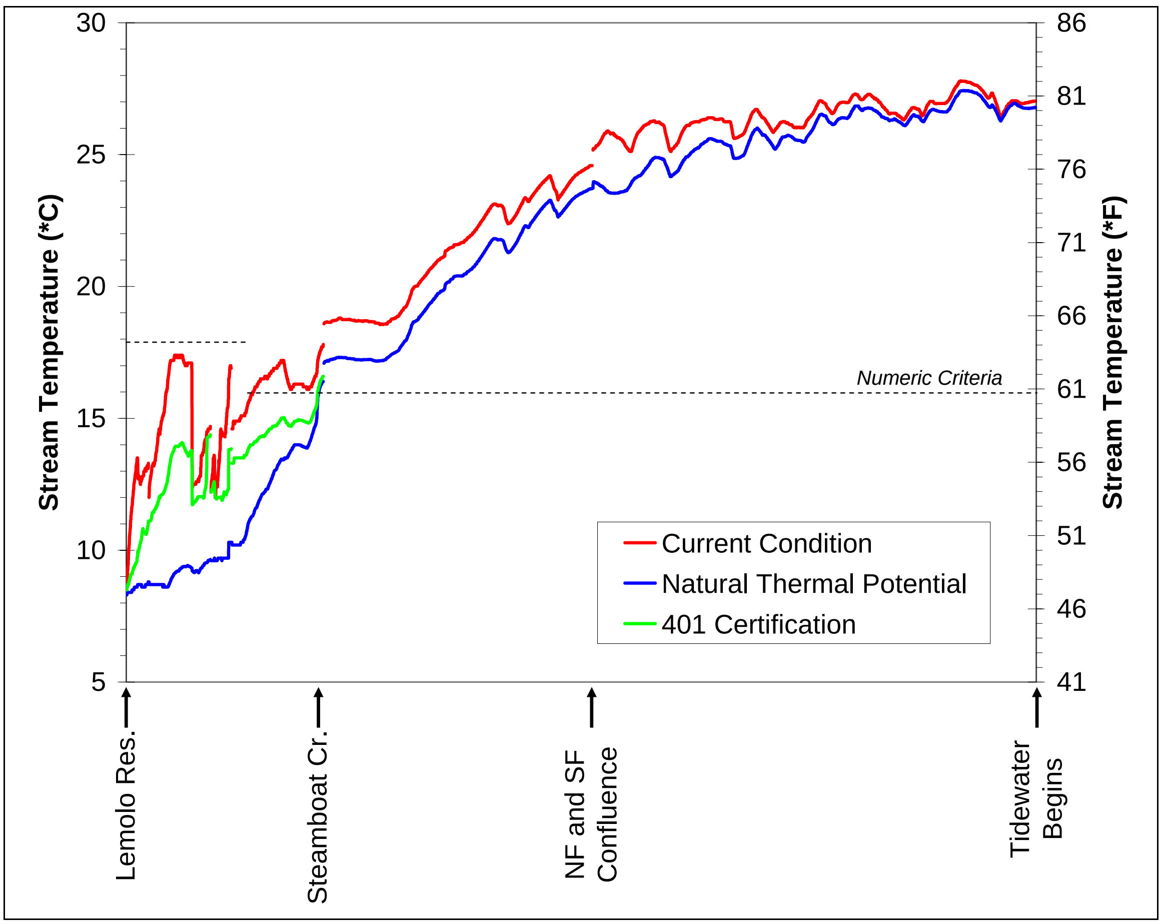


Figure 3.39 **North Umpqua River and Umpqua River temperature simulation results.**

3.7.22 Temperature Simulation Results Summary

Figure 3.41 summarizes the stream temperature simulation results. The bar graph shows the stream mileage categorized by temperature ranges for the current condition and natural thermal potential. The line graph depicts the shift in overall temperature regime from warmer to cooler conditions in the natural thermal potential scenario.

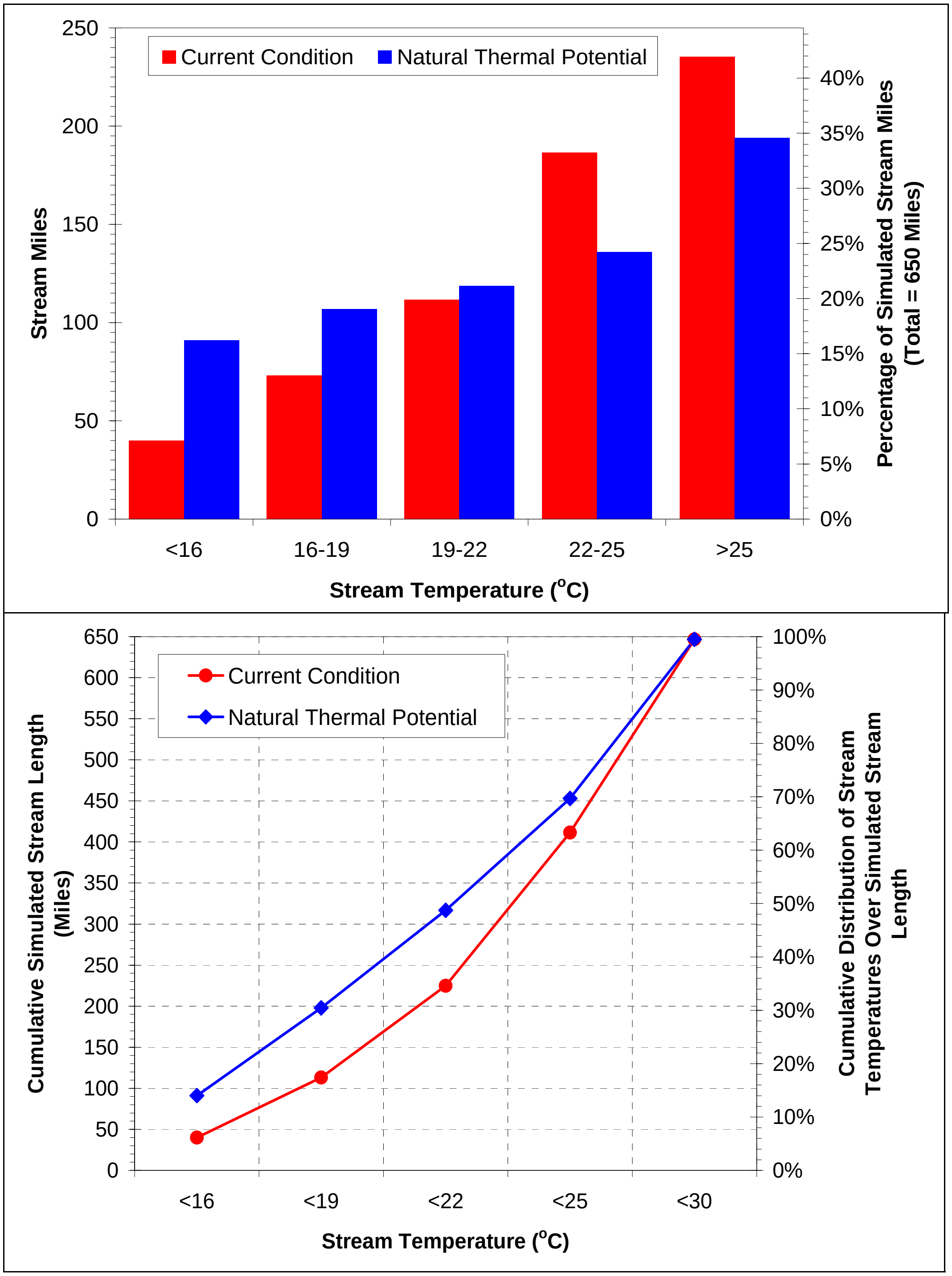


Figure 3.40 **Distributions of simulated stream temperatures in the Umpqua River Basin.**

Figure 3.42 contains maps showing the spatial distributions of current and natural thermal potential stream temperatures.

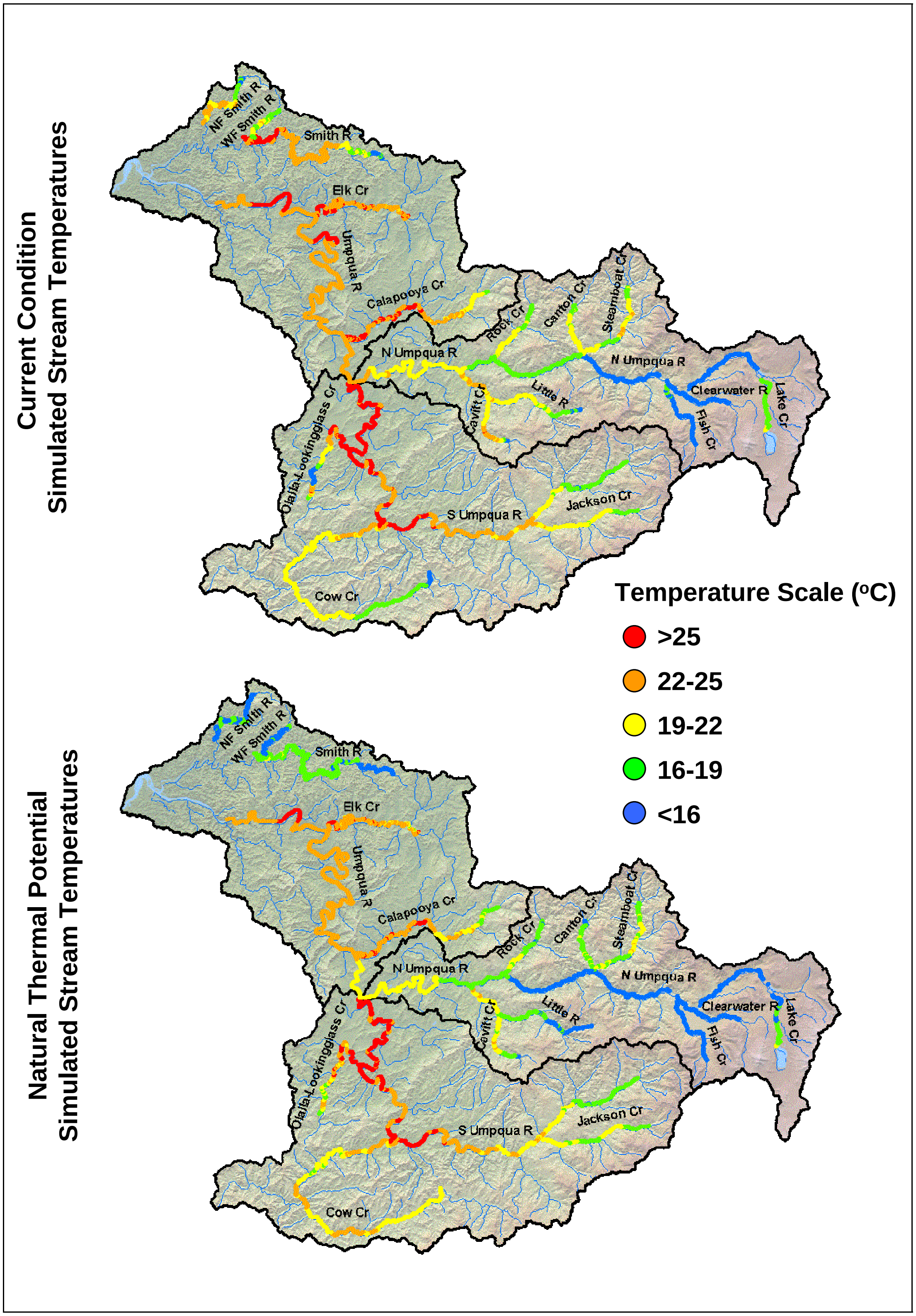


Figure 3.41 **Simulated stream temperatures.**

Figure 3.43 contains maps showing the spatial distributions of current and potential effective shade.

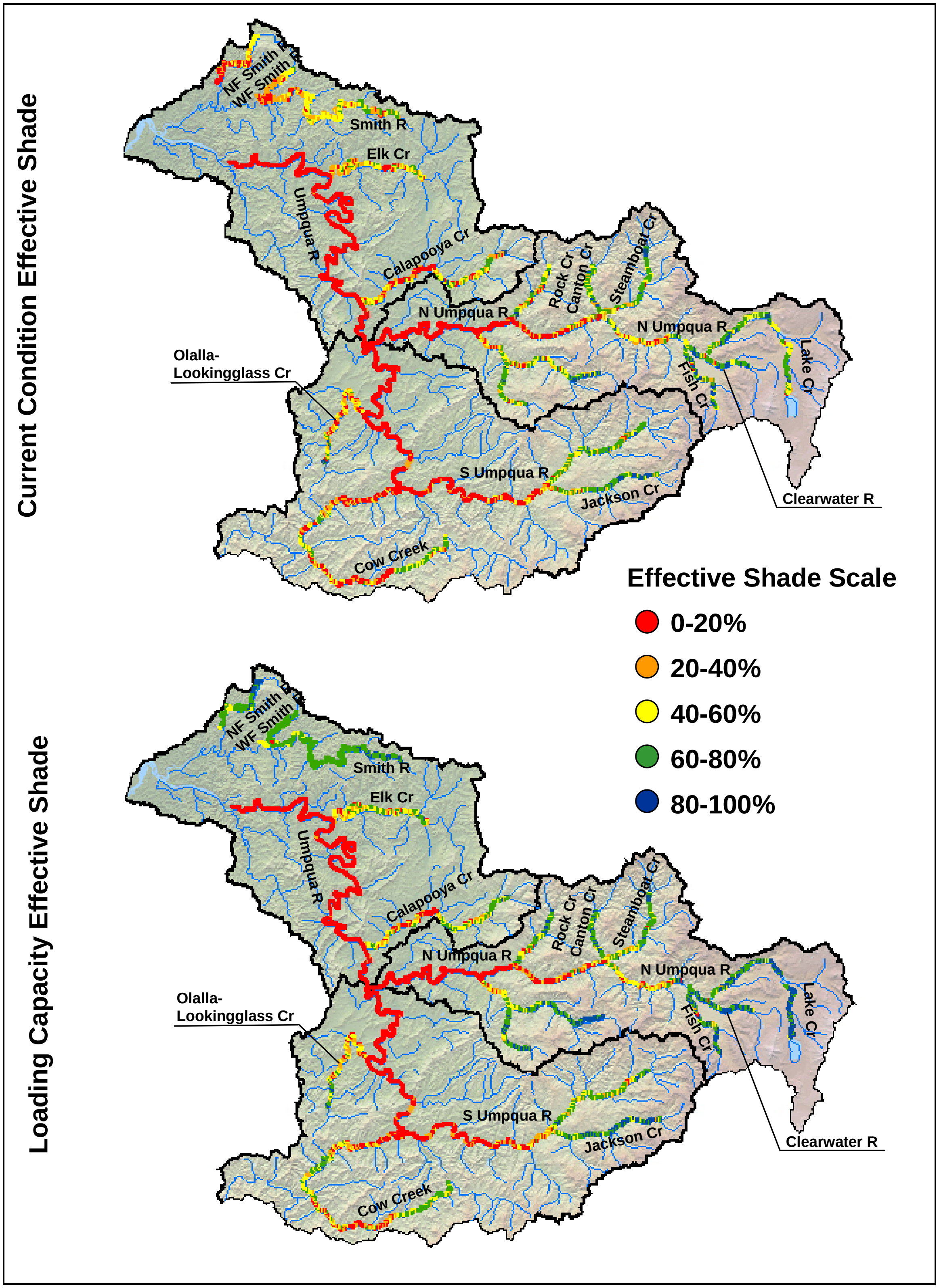


Figure 3.42 Simulated effective shade for current conditions and loading capacity.

3.8 MARGINS OF SAFETY

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

The MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS 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 MOS documented. The MOS is not meant to compensate for a failure to consider known sources. Table 3.11 presents six approaches for incorporating a MOS into TMDLs.

A TMDL and associated MOS, which results in an overall allocation, represent the best estimate of how standards can be achieved. The selection of the MOS 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 3.11 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 MOS.
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 description of the *implicit* MOS for the Umpqua Basin Temperature TMDL begins with a statement of assumptions. An *implicit* MOS has been incorporated into the temperature assessment methodology. Conservative estimates for unmeasured data were used in the stream temperature simulations are are listed below. For further information regarding stream temperature modeling assumptions, refer to the **Umpqua River Basin Temperature TMDL Appendix**.

- Simulations were performed with conservative estimates of groundwater flow and its behavior within the substrate. Groundwater has a cooling influence on stream temperatures and more robust modeling is required to factor in its complete potential to cool streams. The conservative estimate of groundwater influence is considered a margin of safety.

- Simulations were performed with wind speeds at zero or at low levels of recorded data. Wind speeds are a component to evaporation, a cooling influence on stream temperatures. The conservative estimate of wind speed is considered a margin of safety.

- DEQ simulated a number of natural disturbance scenarios and its effects on the natural thermal potential river temperature. While it is debatable which level is the appropriate severity of natural disturbance over a long time period, allocations were developed based on the highest range of natural disturbance. Any amount less therefore creates the conditions for cooler stream temperatures. Using the highest level of natural disturbance to develop allocations is considered a margin of safety. See Section 5 in the technical appendix for more discussion on natural disturbance.

- Natural condition simulations used to develop the natural thermal potential river temperatures used riparian vegetation overhang values of zero. As riparian vegetation increases, particularly during the late seral stages, the potential for vegetation to overhang the stream is very high. More area of stream that is shaded from direct sunlight keeps streams from warming. This conservative estimate of overhang is considered a margin of safety.

- Simulations of point source impacts used to develop waste load allocations assumed sources were discharging at their effluent design flows and maximum effluent temperatures at all times. Waste load allocations do not exceed the human use allowance nor is it expected that all sources will be discharging at their maximum levels at the same time or all the time. This conservative factor will yield a cooler river and is considered a margin of safety.