UPPER SOUTH FORK COQUILLE TOTAL MAXIMUM DAILY LOAD (TMDL) and WATER QUALITY MANAGEMENT PLAN (WQMP)

Prepared by the Oregon Department of Environmental Quality

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TMDL SUMMARY
South Fork Coquille River
(Upper HUC)

Prepared by

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TABLE OF CONTENTS

Table 1. South Fork Coquille Watershed TMDL Components	
State/Tribe: Oregon Waterbody Name(s): All perennial streams within the 5th field HUC (hydrologic unit code) 1710030501– South Fork Coquille watershed, RM 70 to headwaters. ***(See figure 6 page 15 of WQMP)*** Point Source TMDL: x Nonpoint Source TMDL: X (check one or both) Date: December 1999	
Component	***Comments***
Pollutant Identification	Stream temperature is an expression of *Heat Energy per Unit Volume* and is expressed in English Units as Btu per cubic feet. *Pollutant:* Heat Energy *Anthropogenic Contribution:* Excessive Solar Energy Input
Target Identification *CWA 303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards* **Temperature: OAR 340-41-365(1)(b)(A)** The seven day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department-approved basin surface water management plan: **64°F (17.8°C)** or- **55°F (12.8°C).** Where **55°F (12.8°C)** applies during times and in waters that support salmonid spawning, egg incubation and fry emergence from the egg and from the gravel. *Loading Capacities* • No more than 439 $Btu \cdot ft^{-2} \cdot day^{-1}$ solar loading as an average measured value over perennial stream length, or attainment of effective shade resulting in site potential or climax solar radiation loading.
Existing Sources *CWA 303(d)(1)*	*Anthropogenic sources of thermal gain from riparian vegetation removal:* • Forest and road management within riparian areas *Anthropogenic sources of thermal gain from channel modifications:* • Timber Harvest, Related silvicultural activities, Roads, Mining
Seasonal Variation *CWA 303(d)(1)*	*Condition*: Based on USFS data (1994 to 1998) *Flow*: Low flow associated with maximum stream temperatures *Critical Conditions*: Increase desirable riparian vegetation to provide effective shade as determined by site potential (climax) conditions. *Inputs*: Solar radiation increased by more exposed stream surface area as a result of decreased effective shade and increased channel width.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*WLAs*: Zero waste load allocation for NPDES permit 0700 J (recreational mining) activities. *LAs:* Effective shade levels (site potential, climax shade conditions). 100 % natural condition, 0% anthrpogenic (federal and private forest lands both receive 0% load allocations)
Margins of Safety *CWA 303(d)(1)*	Margins of Safety demonstrated in critical condition assumptions regarding groundwater inflow and within shade and channel assessments.
WQS Attainment Analysis *CWA 303(d)(1)*	• Statistical demonstration of temperature related to current shade conditions. • Analytical assessment of simulated temperature change related to allocated solar loading.
Public Participation (40 CFR 25)	***See page 38 of the WQMP in addition to information contained herein.***

1. INTRODUCTION

This TMDL Summary seeks to clearly address elements required by EPA to meet the requirements for Total Maximum Daily Load (TMDL) development. These elements are predominately addressed in the accompanying Water Quality Management Plan (WQMP). This WQMP was prepared by local partners and the Oregon Department of Environmental Quality (DEQ). This Summary will both help guide the reviewer to these elements contained within the WQMP and provide additional supporting information.

OREGON'S TOTAL MAXIMUM DAILY LOAD PROGRAM (GENERALLY DEFINED)

The quality of Oregon's streams, lakes, estuaries and groundwaters is monitored by DEQ and a variety of other partners. This information is used to determine whether water quality standards are being violated and, consequently, whether the *beneficial uses* of the waters are being threatened. *Beneficial uses* include fisheries, aquatic life, drinking water, and recreation. Specific State and Federal plans and regulations are used to determine if violations have occurred: these regulations include the *Federal Clean Water Act* of *1972* and its amendments 40 *Codified Federal Regulations* 131, and *Oregon's Administrative Rules* (**OAR Chapter 340**) and *Oregon's Revised Statutes* (**ORS Chapter 468**).

The term *water quality limited* is applied to streams and lakes where required treatment processes are being used, but violations of State water quality standards occur. With a few exceptions, such as in cases where violations are due to natural causes, the State must establish *a Total Maximum Daily Load* or *TMDL* for any waterbody designated as *water quality limited*. A *TMDL* is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards.

The total permissible pollutant load is allocated to point, nonpoint, background, and future sources of pollution. *Wasteload Allocations* are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The *Wasteload Allocations* are used to establish effluent limits in discharge permits. *Load Allocations* are portions of the *Total Maximum Daily Load* that are attributed to either natural background sources, such as soils, or from nonpoint sources, such as agriculture or forestry activities. *Allocations* can also be set aside in reserve for future uses. Simply stated, *allocations* are quantified measures that assure water quality standard compliance. The *TMDL* is the integration of all developed *allocations*.

Recently several agencies have been mandated to take proactive roles in developing management strategies in the Coquille River Basin. Water quality management plans for forested, agricultural, and urban lands that address both nonpoint and point sources of pollution basin wide are currently under development. It is imperative that these plans consider the relatively robust data that describe water quality, instream physical parameters and landscape features. These management efforts will require stakeholders, land managers, public servants and the general public to become knowledgeable with water quality issues in the Coquille River Basin.

2. GEOGRAPHIC DESCRIPTION

(See Element 1 WQMP page 6-12)

A TMDL has been developed to address fisheries concerns for the upper South Fork Coquille River Subbasin and all it's major perennial tributaries. The TMDL builds upon management activities defined within the Oregon's Forest Practices Act and the Northwest Forest Plan and Forest Ecosystem Management Assessment Team (FEMAT) protection/restoration measures.

The geographic scope of this TMDL effort focuses on the upper portion of the South Fork Coquille Subbasin. It comprises an area managed primarily by the United States Forest Service (USFS) with smaller holdings managed by private timber interests. The lower portion of the South Fork Coquille Subbasin will be submitted as a discrete landscape piece. The watershed was divided as such to facilitate subsequent planning efforts. The lower watershed has diverse ownership and ongoing TMDL assessment in this area is well served by utilizing this completed assessment for the upper hydrologic unit .

The 1996 TMDL completed for the Coquille River addresses dissolved oxygen only and applies only to the mainstem segment of the Coquille River.

The decision was made to approach the South Fork Coquille TMDL assessment in two discrete segments (two discrete 5th field watersheds). It was determined that working from headwaters downstream represented a valid approach to TMDL assessment. This decision was based upon a number of factors.

- Significant changes in channel morphology occur in the lower South Fork. Unlike the upper South Fork unit the lower South Fork unit channel is deeply incised and active and severe bank erosion is occurring. Sediment loading from the upper unit can and has likely had influences on the lower unit channel morphology. This channel condition is limiting to vegetation management.
- Water temperatures dramatically increase below the upper unit. Determination of potential water quality improvements from the upper unit will allow an improved and focused lower unit assessment.
- Assessment at the 5th field level better supports 7th field planning for restoration and enhancement activities.

Information generated in the upper unit assessment is critical to the lower unit assessment. Conducting these assessment sequentially will provide guidance and improved focus to the lower unit assessment.

Information generated in the upper South Fork assessment will be the starting point for the lower unit assessment. It will provide valuable information regarding what improvement might be realized and what water quality improvements might be expected from the upper unit. The upper unit provides the dominant influence on the water quality regime in the lower mainstem of the South Fork.

The lower unit assessment will focus on mainstem channel instability, subsequent lack of vegetation, and water consumptive uses. Objectives to achieve improved channel stability, vegetative buffers, and augment flows will be defined. The lower unit assessment will also focus upon mainstem tributaries as the primary juvenile summer rearing habitat and the refugia that they provide in a heated mainstem.

The lower unit channel and riparian assessments are currently underway and scheduled for completion in 2002. Information gleaned in the upper unit assessment will be integrated. As land use diversifies, management planning will expand to encompass these uses.

This approach is in no way intended to undermine the concept that a stream is a continuum where one part of the system relies on others to function correctly. Management plans will recognize this connectivity and reflect basin wide concerns and corresponding management needs. DEQ will continue to develop it's TMDL's and WQMP's based on the basin connectivity philosophy.

The South Fork Coquille Subbasin, part of the Coquille river basin, is home to productive forested lands and has the distinction of containing streams with historically abundant salmonid populations. Valuable contributions from forestry, fisheries, and local watershed organizations in the Coquille watershed have prompted extensive data collection and study of the interaction between land use and water quality. The knowledge derived from these data collection efforts and academic study, some of which is presented in this document, have been used by land managers to design protective and enhancement strategies that are actively being applied to address water quality issues. The development of this TMDL and WQMP provides improved assessment information from which to plan restoration and enhancement efforts.

The data review contained in this TMDL document summarizes the varied, yet extensive, data collection and studies that has occurred through many years in the South Fork Coquille Subbasin. Regional Water quality programs are already utilizing this information to develop and/or alter water quality management efforts. In addition, this TMDL should be used to track water quality, instream physical parameters, and landscape conditions that currently exist. In the future it will be important to determine the adequacy of planned water quality improvement efforts. Looking back at this TMDL it will be possible to track the changes that have occurred in water quality, instream, and landscape parameters that affect fish, as well as people, in the upper South Fork Coquille Subbasin.

This TMDL builds upon the protection/restoration measures prescribed by the Northwest Forest Plan and the Forest Practices Act (FPA). The area covered by the TMDL and WQMP includes land managed primarily by the USFS with private timber ownership in the upper fringes of the watershed ***(see page 7 WQMP for map).*** This portion of the South Fork Coquille River is a tier 1 key watershed as defined by the President's Northwest Forest Plan (1994, USDA, USDI). Private forested lands are managed under the Oregon Forest Practices Act (FPA). Of the 84,750 acres within this portion of the South Fork Coquille Watershed, 60,670 are managed by USFS, 16,000 by The Timber Company and the remaining 8,080 acres are managed by several other private timber land managers. The USFS and the Timber Company worked closely together in the development of a WQMP for this area.

Recreational mining is conducted within the watershed and is considered a point source activity. It is the only point source activity present in the assessment area.

3. APPLICABLE WATER QUALITY STANDARDS

TEMPERATURE

A seven-day moving average of daily maximums (7-day statistic) was adopted as the statistical measure of the stream temperature standard. Absolute numeric criteria are deemed action levels and can determine water quality standard compliance (**Table 1**). The numeric criteria adopted in Oregon's water temperature standard rely on the biological temperature limitations considering sensitive *indicator species*. An extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers (ODEQ, 1995)*.

Table 1. Applicable Water Temperature Standards *OAR 340-41-725(2)(b)(A)*	
Water Temperature Standard	**7-Day Statistic**
Basic Absolute Criterion – Applies year long in all streams in the basin, with the exception of those that qualify for the *salmonid spawning, egg incubation and fry emergence criterion* -or- *bull trout criterion*.	≤64°F (17.8°C)
Salmonid Spawning, Egg Incubation and Fry Emergence Criterion – Applies to stream segments designated as supporting native salmonid spawning, egg incubation and fry emergence for the specific times of the year when these uses occur.	≤55°F (12.8°C)
Bull Trout Criterion – Applies to waters determined by the Department to support or to be necessary to maintain the viability of Bull Trout in the basin.	≤50°F (10.0°C)

The Oregon Environmental Quality Commission has adopted numeric and narrative water quality standards to protect designated *beneficial uses*. In practice water quality standards have been set at a level to protect the most sensitive uses and seasonal standards may be applied for uses that do not occur year round. Cold-water aquatic life such as salmonids and trout are the most sensitive *beneficial uses* in upper South Fork Coquille Watershed. In this forested watershed, concerns related to the effects of excessive water temperatures on rearing of salmonid fish have been well documented.

No data was available for use in determining system compliance with temperature criteria designed to be applied at times and in waters that support salmonid spawning, egg incubation and fry emergence from the egg and from the gravel. DEQ is committed to determine the status of this system for this criteria through future monitoring efforts.

Implementation Program Applicable to All Basins (340-41-120) states:

- 11(a) It is the policy of the Environmental Quality Commission (EQC) to protect aquatic ecosystems from adverse surface water warming caused by anthropogenic activities. The intent of the EQC is to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming of surface waters, to encourage the restoration of critical aquatic habitat, to reverse surface water warming trends, to cool the waters of the State, and to control extremes in temperature fluctuations due to anthropogenic activities:

- 11(A) The first element of this policy is to encourage the proactive development and implementation of best management practices or other measures and available temperature control technologies for nonpoint and point source activities to prevent thermal pollution of surface waters.

- 11(c) The temperature criteria in the basin standards establish numeric and narrative criteria to protect designated beneficial uses and to initiate actions to control anthropogenic sources that adversely increase or decrease stream temperatures. Natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions. These exceedances are not water quality standards violations when the natural conditions themselves cause water temperatures to exceed the numeric criteria. In these situations the natural surface water temperatures become the numeric criteria. In surface waters where both natural and anthropogenic factors cause exceedances of the numeric criteria, each anthropogenic source will be responsible for controlling, through implementation of a management plan, only that portion of temperature increase caused by the anthropogenic source.

HABITAT MODIFICATION: OAR 340-41-325(2)(I)

Habitat modification issues and goals are discussed in Element 1 WQMP Condition Assessment , beginning on page 20.

The creation of tastes of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed.

Habitat modification is not the direct result of a pollutant although it does affect beneficial uses. Because a pollutant is not the cause, the concept of establishing a loading capacity and allocations does not apply. There is the expectation, however, that the improvements to riparian vegetation that will be necessary to meet the shade, channel width, and width to depth ratio surrogates will also lead to improvements in habitat.

SOUTH FORK COQUILLE WATER QUALITY IMPAIRMENTS

Supporting temperature data see Element 2 WQMP table 2

As a result of water quality standards (WQS) exceedances for temperature, four stream segments are included on Oregon's 1998 §303(d) list. Monitoring has shown that water quality in the South Fork Coquille Subbasin often does not meet State water quality standards all of the time. The narrative and numeric standards for *temperature* and *habitat modification* are not achieved in the mainstem reaches of the South Fork as well as in two tributaries where data is available. Some tributary monitoring indicates that areas of the watershed do achieve WQ standards even during peak loading periods. **Table 2** lists the reaches §303(d) listed for temperature, the applicable criterion that is exceeded, and listed stream miles. In addition, this TMDL addresses potential water quality impairment for seven significant tributary streams within the upper South Fork Coquille Subbasin that are not currently on Oregon's 1998 §303(d) list. A watershed approach was applied during assessment.

USFS and Private Timber Managed Lands 303(d) listed Segments, Applicable Water Quality Standards *, and Stream Miles Listed			
South Fork Coquille River Johnson Creek to Headwaters	Temperature 303d listed	*OAR 340-41-325(2)(b)(A)*	21 Miles
South Fork Coquille River RM 70 to Johnson Creek (sub set of Yellow Creek to Johnson Creek listing)	Temperature 303d listed	*OAR 340-41-325(2)(b)(A)*	8 miles
Rock Creek: Mouth to RM 3	Temperature 303d listed	*OAR 340-41-325(2)(b)(A)*	3 Miles
Johnson Creek: Mouth to Headwaters	Temperature 303d listed	*OAR 340-41-325(2)(b)(A)*	19 Miles
Rock Creek	Hab. Mod. 303d listed	*OAR 340-41-325(2)(I)*	10 Miles
Significant tributaries (7)	Temperature	Headwaters and significant tributaries not specifically identified by name on 303d list	39 Miles
Total stream miles assessed			**97 Miles**

Excessive summer water temperatures in several tributaries and the South Fork Coquille River mainstem are reducing the quality of rearing habitat for chinook and coho salmon, as well as steelhead trout. Primary watershed disturbance activities examined within this TMDL include forest management within riparian areas, timber harvest in sensitive areas outside the riparian zone, sediment delivery, road management, historic removal of instream structure, instream mining practices, and consumptive water withdrawals. No agricultural activities are conducted within the assessed area.

Section 303(d) of the Federal Clean Water Act (1972) requires that water bodies that violate water quality standards, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list. Following further assessment, *Total Maximum Daily Load* (TMDL), will be implemented to restore water quality. In addition to watershed condition assessment and problem statements, a water quality management plan (WQMP) requires identification of water quality goals and objectives, designation of responsible parties, implementation of the management plan (TMDL), some measure of assurance that the plan (TMDL) will actually be implemented, and a monitoring of feedback loop (DEQ WQMP guidance 1997).

BENEFICIAL USES

Oregon Administration Rules (**OAR 340–41–322 Table 3**) lists the designated beneficial uses for South Coast Basin waters. The specific beneficial uses *occurring* in the South Fork Coquille Subbasin are presented in **Table 3**.

Table 3. Beneficial uses occurring in the South Fork Coquille Subbasin

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply (campgrounds only)	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply		Salmonid Fish Spawning	✓
Industrial Water Supply		Salmonid Fish Rearing	✓
Irrigation (Fire Suppression only)	✓	Resident Fish and Aquatic Life	✓
Livestock Watering		Wildlife and Hunting	✓
Boating		Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	

Numeric and narrative water quality standards are designed to protect the most sensitive *beneficial uses*. In the upper South Fork Coquille Subbasin, resident fish and aquatic life and salmonid spawning and rearing are designated the most sensitive *beneficial uses*.

Element 1 WQMP Figure 3 graphically displays fish distribution within this area.

Aquatic life is sensitive to water temperature. Salmonid fishes, often referred to as cold water fish, and some amphibians appear to be highly sensitive to temperature. In particular, Coho salmon and Spring Chinook are among the most temperature sensitive of the cold water fish species within this basin. Oregon's water temperature standard employs logic that relies on using these *indicator species,* which are the most sensitive. If temperatures are protective of *these indicator species*, other species will share in this level of protection. Coho salmon have been allotted protection (listed) under the Endangered Species Act as threatened species in the Upper South Fork Coquille Subbasin.

Thermally induced stresses can result in fish mortality. This can be attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced stress and/or mortality, termed indirect or *sub-lethal*, is more delayed, and occurs weeks to months after the onset of elevated temperatures.

4. PROBLEM ASSESSMENT

See Element 1 and 2 WQMP Condition Assessment pg. 12-26

Decreased effective shade levels result from lack of adequate riparian vegetation available to reduce sunlight (e.g. solar energy from incoming solar radiation). Human activities that have contributed to degraded water quality conditions in the South Fork Coquille Subbasin include timber harvest, road building, road management, excessive upland sediment loading, and instream mining. Stream channel widening can increase the stream surface area exposed to heat transfer from solar radiation

Riparian area and channel morphology disturbances have resulted from past timber management, agricultural activities, and mining land uses. These sources of pollution primarily affect the water quality parameter (temperature) through increased solar loading by: (1) increasing stream surface solar radiation loading and (2) increasing stream surface area exposed to solar radiation loading. Although timber harvest and mining continue in the South Fork Coquille Subbasin, altered management practices that comply with surrogate measures (allocations) presented in this document are intended to ameliorate pollutant delivery.

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, the condition of the riparian area, channel morphology, and hydrology can be affected by land use activities. Assessment of the elevated summertime stream temperatures attributed to anthropogenic causes in the upper South Fork Subbasin included the evaluation of the following parameters:

1. *Channel widening (increased width to depth ratios) that increases the stream surface area exposed to energy processes, namely solar radiation,*
2. *Riparian vegetation disturbance that compromises stream surface shading, riparian vegetation height and density (shade is commonly measured as percent effective shade),*
3. *Reduced summertime base flows that result from instream withdrawals per instream water rights.*

Since consumptive use within the forest boundary accounts for less than one percent of the total low flow discharge at the forest boundary, water withdrawals above the Forest boundary in the upper South Fork Coquille Subbasin are not considered a major contributor to stream temperature increases.

See Element 1 WQMP page 21 for more detailed information regarding flow assessment.

The effects of sediment on channel form (and eventually temperature) were identified and analyzed with historic air photos and direct field measurement of width to depth ratios and pool depth. The objective was to find areas where aggradation and channel widening have occurred and to what extent are they recovering. The primary focus was on specific low gradient reaches along the mainstem of the South Fork Coquille and the lower portion of Rock Creek. These are reaches where impacts have occurred and considerable amounts of solar radiation hit the water surface because shading does not reach the stream. It should be noted that most stream reaches within the South Fork Coquille above the Forest Boundary have significant sediment transport capacity for sand and gravel sized materials. Consequently, the effects from these sediment sizes are likely seen lower in the system.

This TMDL analysis determined that management related sediment will have an impact on the channel width in the system, although the largest impacts will likely be realized below the Forest Boundary, and that efforts to reduce management related inputs will be implemented. Some channel width to depth ratio improvements are predicted, the benefits of which are housed in *Margin of Safety* and as such were not utilized in modeling future conditions.

Analysis presented in this TMDL will demonstrate that developed solar loading capacities will ensure attainment of narrative State water quality standards. Specifically, the link between shade surrogate measures (allocations) for solar radiation loading capacities and water quality attainment will occur via two processes:

1. *Remove human (anthropogenic) solar radiation contributions from temperature dynamics in the upper South Fork Coquille Subbasin, and*
2. *Restore riparian reserves that function to protect stream morphology and encourage bank building processes in severe hydrologic events.*

STREAM TEMPERATURE ASSESSMENT

Stream temperature is an expression of heat energy per unit volume, which in turn is an indication of the rate of heat exchange between a stream and its environment. The heat transfer processes that control stream temperature include solar radiation, longwave radiation, convection, evaporation and bed conduction (Wunderlich, 1972; Jobson and Keefer, 1979; Beschta and Weatherred, 1984; Sinokrot and Stefan, 1993; Boyd, 1996). With the exception of solar radiation, which only delivers heat energy, these processes are capable of both introducing and removing heat from a stream.

Anthropogenic increase in heat energy is derived from solar radiation as increased levels of sunlight reach the stream surface and raises water temperature. The pollutant (solar heat energy) is a source of stream temperature increase that is within management measures and is targeted in this TMDL.

MECHANICS OF SHADE

Stream surface shade is a function of several landscape and stream geometric relationships. Some of the factors that influence shade are listed in **Table 5**. In the Northern Hemisphere, the earth tilts on its axis toward the sun during summertime months allowing longer day length and higher solar altitude, both of which are functions of solar declination (i.e. a measure of the earth's tilt toward the sun). Geographic position (i.e. latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream/riparian orientation. Riparian height, width and density describe the physical barriers between the stream and sun that can attenuate incoming solar radiation (i.e. produce shade). The solar position has a vertical component (i.e. altitude) and a horizontal component (i.e. azimuth) that are both functions of time/date (i.e. solar declination) and the earth's rotation (i.e. hour angle). While the interaction of these shade variables may seem complex, the math that describes them is relatively straightforward geometry, much of which was developed decades ago by the solar energy industry.

Table 5. Factors that Influence Stream Surface Shade

Description	Measure
Season	Date
Stream Characteristics	Aspect, Bankfull Width
Geographic Position	Latitude, Longitude
Vegetative Characteristics	Buffer Height, Buffer Width, Buffer Density
Solar Position	Solar Altitude, Solar Azimuth

Over the years, the term shade has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, shade is defined as the percent reduction of potential solar radiation load delivered to the water surface. Thus, 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 solar loading capacities.

The percent effective shade is perhaps one of the easiest and straightforward stream parameters to monitor/calculate and is most helpful in directing water quality management and recovery efforts. Using solar tables or mathematical simulations, the *potential daily solar load* can be quantified. The *measured solar load at the streams surface* can easily be measured with a Solar Pathfinder© or estimated using mathematical shade simulation computer programs (Boyd, 1996 and USFS, 1993).

Existing Condition Assessment

Effective shade and solar radiation loading were simulated for various channel widths (bankfull). Site potential vegetation is assumed to be late seral Douglas fir and mixed hardwood stands. This vegetative condition was utilized to define effective shade potential. Site potential shading is utilized to predict solar loading without anthropogenic effects. Site potential vegetation defines the solar load while effective shade is the surrogate target. Effective shade may well be achieved in given channel types without site potential vegetation.

See Element 1 WQMP, Riparian reserves, page 9.

In the upper South Fork Coquille Watershed, undisturbed riparian areas generally progress towards late seral woody vegetation communities (mixed hardwood, but conifer dominated). Few, if any, riparian areas in the upper South Fork Coquille are unable to support either late seral woody vegetation or tall growing herbaceous vegetation. Further, the climate and topography are well suited for growth and maintenance of large woody vegetative species in the riparian areas.

WQMP Element 1 table 3 shows the percent existing shade and percent target shade (reach weighted). Table 4 identifies the predicted solar radiation load that would result when riparian conditions reach effective shade targets and/or site potential is achieved.

Observed Longitudinal Stream Heating

WQMP Element 1 Figure 6 displays the stream profile and stream heating as a function of measured perennial stream distance from headwaters.

Generally, stream temperatures follow a longitudinal (downstream) heating pattern, where smaller tributaries are cooler than the mainstem reaches of the upper South Fork Coquille River 1998 mainstem seven day maximum average temperature (close to headwater @ Eden Bridge) are 60.8°F. The mainstem warms roughly 9°F over the 27 miles of stream length to the USFS Boundary at RM 71.

Shade Related to Observed Longitudinal Stream Heating

Longitudinal heating is a natural process. However, rates of heating are dramatically reduced when high levels of shade exist and solar radiation loading is minimal. The overriding justification for the solar loading reduction (loading capacity) is to minimize longitudinal heating. A limiting factor in reducing longitudinal stream heating is the existing effective shade level.

Effective shade at site vegetative potential modeling was conducted utilizing the Shadow Model (USFS, 1993). Shadow model inputs and outputs are provided in Appendix A. In addition, the Heat Source model (Boyd, 1996) was utilized as a predicitve tool to determine what the longitudinal temperature profile would look like with site potential vegetation present. Heat Source modeling results can be found in Appendix C page 13. Based upon the predicted longitudinal stream temperature profile no thermal loads are available for allocation to anthropogenic sources in this system.

No data was available for use in determining system compliance with temperature criteria designed to be applied at times and in waters that support salmonid spawning, egg incubation and fry emergence from the egg and from the gravel. DEQ is committed to determine the status of this system for this criteria through future monitoring efforts. This TMDL was developed to ensure that water is as cool as possible by ameliorating management caused sources of stream heating. The TMDL sets load allocations for solar radiation which establishes effective shade targets needed to meet those load allocations. The load allocations are based on the maximum shade (removal of solar loading) that can potentially be achieved for given stream segments. The effective shade targets, when met, would ensure no increase in water temperature due to anthropogenic sources of stream heating. Meeting the salmonid spawning criteria is therefore an objective of the TMDL. DEQ is in the process of collecting data to determine if temperature spawning criteria are being met. Attainment of desired conditions identified in this TMDL will result in the attainment of the most optimum temperature regimes for spawning, egg incubation, and fry emergence that the area is capable of producing. Site potential conditions should result in maximum shading and more natural temperature patterns during other months of the year.

5. TMDL – LOADING CAPACITIES AND ALLOCATIONS

Regulatory Framework

Under the current regulatory framework for development of TMDLs, identification of the loading capacity is an important first step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. By definition, TMDLs are the sum of the allocations [40 CFR 130.2(i)]. Allocations are defined as the portion of a receiving water loading capacity that is allocated to point or nonpoint sources and natural background. EPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*."

Loading capacities in the upper South Fork Coquille Subbasin are heat energy from incoming solar radiation expressed as Btu/ft^2 per day. Simulations of heat transfer processes indicate that water temperatures increase above natural daily fluctuations when the heat load from solar radiation rises. All streams with significant flow contributions were evaluated (5% area or flow @ confluence).

Solar loading capacities are determined for streams based upon future vegetative potential or vegetative site potential. In this assessment the potential to provide measurable shade increases was evident, but, even with this shade increase, the system is not expected to attain the temperature standard under extreme environmental conditions. In this case, a site potential vegetation target will provide maximum shade or effective shade. Therefore, the loading capacity will be set at the site potential vegetative state and no thermal load will be available to allocate to anthropogenic sources.

Site potential vegetation, target shade, and solar radiation loading take into account bankfull channel width and stream orientation for late July and early August. This approach can also be used to determine site potential loading capacity and effective shade conditions for those streams in the South Fork Coquille River Subbasin lacking a site potential analysis. Appendix A identifies potential target shade values ranging from a low of 61% in the mainstem where channel wetted widths are 75 feet to 96% where channel wetted widths are 4 feet. The site potential (target shade value) of 82% is the result of weighted averaging based upon reach length and total length of perennial stream assessed.

WQMP Element 1 Table 3 lists the existing and site potential (effective shade) shade target values for the upper South Fork Subbasin. WQMP Table 4 provides existing and target solar loading for the entire assessed area with supporting information in Appendix A.

A target solar loading capacity (based upon site potential vegetative conditions) of 439 Btu/ft^2 per day has been derived from reach weighted potential shade modeling. This load is based upon the reach weighted effective shade potential for the sub basin.

In terms of water temperature increases, the principle source of heat energy is solar radiation directly striking the stream surface. The total energy budget for upper South Fork Coquille Subbasin is;

- Current Solar Loading = 927 $Btu \cdot ft^{-2} \cdot day^{-1T}$
- Targeted loading capacity condition, Solar Loading Capacity = 439 $Btu \cdot ft^{-2} \cdot day^{-1}$

Note that the targeted solar loading capacity condition results in significant diurnal heat energy reductions as indicated in Appendix C. This modeling exercise included the mainstem only. Target solar loading for this part of the system only was determined to be 610 $Btu \cdot ft^{-2} \cdot day^{-1T}$. The modeling day selected depicts seasonal worst case conditions. Solar radiation has been determined to be the predominant heat energy process in the current condition simulation.

WATER QUALITY ATTAINMENT - TEMPERATURE CHANGE RELATED TO SOLAR LOADING CAPACITIES

Predictive temperature modeling was conducted using Heat Source (Boyd,1996). This model examines both the total energy transfer rates to the stream (i.e. the sum of heat energy transfer processes) and the response of water temperature to heat energy absorbed. Heat transfer processes considered in the analysis include solar radiation, longwave (thermal) radiation, convection, evaporation, and streambed conduction. This analysis has been developed using typical streamflows and channel characteristics commonly found in the upper South Fork Coquille Watershed as well as conservative assumptions described in the margin of safety discussion. **Appendix C** displays simulated mainstem expected temperatures under future site conditions. The modeling day selected depicts seasonal worst case conditions.

Anthropogenic sources provide no measurable increase in stream temperature when solar radiation loads are equal to or less than the loading capacity for the assessed area (Targeted Solar Loading = 439 $Btu \cdot ft^{-2} \cdot day^{-1}$). As demonstrated by simulation results, stream heating is a function of streamflow. Lower flows correspond to increased stream heating. Solar radiation loading of 439 $Btu \cdot ft^{-2} \cdot day$ represents a reasonable starting point for defining loading capacity (i.e. the greatest amount of loading that surface waters can receive without violating narrative water quality standards). Average flat plane solar radiation loads above the riparian canopy in late July to early August are on the order of 2440 $Btu \cdot ft^{-2} \cdot day^{-1}$. Reach weighted shade target assessment has determined that an 82% reduction in <u>potential solar radiation</u> load delivered to the water surface defines another target (*or "appropriate measure*") which can be used for TMDL development. This represents a target shade reach weighted average shade value, summarized in tables 3 and 8 of the WQMP by watershed. Specific site potential condition by reach are included in Appendix A, Shadow modeling. Again, effective shade does vary per specific site based primarily upon aspect and channel width.

SURROGATE MEASURES - DEFINED

The South Fork Coquille Subbasin TMDL incorporates measures other than "*daily loads*" to fulfill requirements of 303(d). Although a loading capacity for heat is derived [e.g. 439 British Thermal Units (Btu) per square foot per day], it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat loads, the South Fork Coquille Subbasin TMDL allocates "*other appropriate measures*" (or surrogates) as provided under EPA regulations [40 CFR 130.2(i)]. The specific surrogate used is *percent effective shade.*

A loading capacity of BTU's per day is not very useful in guiding nonpoint source management practices. Percent effective shade is a surrogate measure that can be calculated directly from the loading capacity. Additionally, percent effective shade is simple to quantify in the field or through mathematical calculations.

Surrogate Measures (*"other appropriate measures"*) are used in conjunction with heat **Load Capacity** targets to address water temperature increases. Namely, *percent effective shade* is an effective measure of anthropogenic heat contributions and a descriptor of riparian condition. In essence, the **Surrogate Measure** (percent effective shade) is **Allocated** as a translation of the developed solar radiation **Loading Capacities**.

Because factors that affect water temperature are interrelated, the surrogate measure (percent effective shade) relies on restoring/protecting riparian vegetation to increase stream surface shade levels, reduce stream bank erosion and stabilize channels. Likewise, narrower channels still require riparian vegetation to provide channel stability and shade, thus reducing heat loads (unless confined by canyon walls or shaded by topography).

Effective shade screens the water's surface from direct rays of the sun. Highly shaded streams often experience cooler stream temperatures due to reduced input of solar energy (Brown 1969, Beschta et al 1987, Holaday 1992, Li et al 1994). Stream surface shade is dependent on topography as well as riparian vegetation type, condition, and shade quality. Over the years, the term shade has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, shade is defined as the percent reduction of potential solar radiation load delivered to the water surface. Thus, the role of effective shade in this TMDL is to prevent or reduce heating by solar radiation.

EFFECTIVE SHADE SURROGATE MEASURES (ALLOCATIONS)

Allocations in the upper South Fork Coquille Subbasin TMDL are derived using heat loads. Percent effective shade (surrogate measure) can be linked to specific areas and, thus, to management actions needed to solve problems that cause water temperature increases (USFS 1993).

WQMP Element 2 Table 8 lists loading capacities for the South Fork Coquille River Watershed (current shade and future effective shade) per assessment segment in column 4, Projected Values.

WATER QUALITY ATTAINMENT - TEMPERATURE CHANGE RELATED TO SHADE SURROGATE MEASURES

Information found in the WQMP is presented in a manner consistent with the definition of effective shade in this TMDL (i.e. the percent reduction of potential solar radiation load delivered to the water surface). This provides an alternative target (or surrogate) which relates to stream temperatures, in this case, an 82% reach weighted average reduction in potential solar radiation delivered to the water surface (i.e. 82% effective shade). By implementing this TMDL anthropogenic activities relating to stream heating will be eliminated.

Please refer to stream temperature simulation results in **Appendix C**. These results clearly demonstrate that decreasing levels of solar radiation can have a dramatic stream cooling effect. Language that is more precise would describe the effect of decreased solar loads as preventing stream temperature increases. Simulation results suggest that thermal conditions in the South Fork Coquille River Watershed can have quite different temperature regimes when improved riparian conditions are achieved. The chart on page 13 of Appendix C illustrates that simulated peak stream temperatures are reduced on the hottest day of the 1998 temperature season by nearly 10°F. This conclusion is consistent with temperature modeling efforts for other waterbodies in the Pacific Northwest (Brown, 1969; Beschta and Weatherred, 1984; Sullivan and Adams, 1990; Boyd, 1996). Based on this modeling outcome significantly more time will be spent below 64°F in the watershed.

WASTE LOAD ALLOCATIONS

Recreational mining is conducted within the watershed and is considered a point source activity. It is the only point source activity present in the assessment area. As currently conducted, this activity is not effecting riparian and/or channel conditions. This activity is currently managed under the 0700J General NPDES Permit. No waste load allocation was established. Point source influences contribute no pollutant load to the system.

6. MARGIN OF SAFETY

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

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, WLAs, and LAs. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. The margin of safety is not meant to compensate for a failure to consider known sources. An implicit margin of safety was developed for this project.

IMPLICIT MARGINS OF SAFETY

Description of the margin of safety for the Upper South Fork Coquille River temperature TMDL begins with a statement of assumptions. Several factors relating to margin of safety have been incorporated into the temperature assessment methodology.

- Groundwater inflow was assumed to be zero and it's cooling influence on stream temperatures via mass transfer/mixing was not accounted for. Further, cooler microclimates associated with late seral conifer riparian zones were not accounted for in the simulation methodology.

- Improving channel conditions are expected through time in reaches one through nineteen along the South Fork mainstem and reaches one and two along lower Rock Creek. These areas have experienced some channel widening and hence should experience recovery as extensive upland sediment abatement projects are implemented and large magnitude storm events reshape channels. Although ***WQMP table 8*** projects channel improvement within a 20 year time frame these channel improvements were not modeled. Current modeling efforts reflect vegetation at a 25 foot offset from the edge of water. These predicted channel improvements provide an additional margin of safety within this TMDL.

- Shadow modeling inputs restricted maximum future shade densities to less than or equal to 70%. Density within any given stand can vary dramatically through seral stages. Even within areas where quite dense stands are present model inputs did not exceed values of 70%. This shade evaluation process likely results in an underestimation of existing and future % shade values.

- Shadow model inputs defaulted to zero % vegetative overhang values. Small stream channels with high shade densities are likely accurately evaluated even with this default because they are easily shaded. In the wider segments of this system, low flow wetted width meander into and out of overhang areas is likely underestimated.

- Tributary temperatures were not changed based upon improved future riparian conditions but held to current temperature regimes. The modeling exercise for this basin focused upon the mainstem. Although significant improvements were predicted for tributary shade no predictive temperature modeling was conducted for tributaries. This decision was made because much of the tributary data remained provisional for private lands in the area. Flow and temperature data sets were not made available for upper tributaries. Temperature and flow sets from only the confluences of these tributaries prohibited predictive temperature modeling. **Likely the most significant cooling expected in the future will be for tributaries within this system.**

- Site potential mature vegetation is assumed to be late seral Douglas fir and mixed hardwood stands. ***(WQMP, Element 1, Riparian reserves, page 9).*** In the upper South Fork Coquille Watershed, undisturbed riparian areas generally progress towards late seral woody vegetation communities (mixed hardwood, but conifer dominated). Site potential tree height during modeling was held to 120’ based upon the mixed community of conifer (180’) and hardwood (120’) expected in the future.

Calculating a numeric margin of safety is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and allocations is the definition of effective shade conditions. Effective shade potential presumed that site potential riparian conditions are the desired future condition for most of the assessment area.

It is understood that human and natural disturbances will likely occur within riparian stands in the future; however, these changes would be very difficult to predict or model. Given the likelihood of future riparian area disturbances, especially from flood and/or fire, the “target” shade increase values predicted by the SHADOW model should be assumed to be a theoretical goal, based on the potential of undisturbed riparian stands to develop shade.

7. SEASONAL VARIATION

Section 303(d)(1) requires this TMDL to be “established at a level necessary to implement the applicable water quality standard with seasonal variations.” Both stream temperature and flow vary seasonally from year to year. Water temperatures are coolest in winter and early spring months. Winter water temperature levels decrease dramatically from summer values, as river flows increase and available solar energy is at an annual minimum. Stream temperatures exceed State water quality standards in summer and early fall, salmonid rearing months (June, July, August and September). Warmest stream temperatures correspond to prolonged solar radiation exposure, warm air temperature, low flow conditions and decreased groundwater contribution. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. The analysis presented in this TMDL is performed during summertime periods in which controlling factors for stream temperature are most critical. The summer of 1998 is recognized as being extremely warm. Ambient air temperatures at the Powers weather station reached 95°F on July 28, 1998. The modeling date selected represented the date that seasonal maximum water temperatures were recorded. This modeling effort hence reflects extreme temperature regimes in this system and clearly depicts the seasonal worst case temperature condition. Future worst case temperatures will certainly run lower than those predicted in Appendix C.

8. REASONABLE ASSURANCE OF IMPLEMENTATION

The area covered by this TMDL and WQMP includes land managed primarily by the USFS with private timber ownership in the upper fringes of the watershed ***(see page 7, Element 1, WQMP for map)***. This portion of the South Fork Coquille River is a tier 1 key watershed as defined by the President’s Northwest Forest Plan (1994, USDA, USDI). Private forested lands are managed under the Oregon Forest Practices Act (FPA). Of the 84,750 acres within this portion of the South Fork Coquille Watershed, 60,670 are managed by USFS, 16,000 by The Timber Company and the remaining 8,080 acres are managed by several other private timber land managers. The USFS and the Timber Company worked closely together in the development of a WQMP for this area. Please see WQMP Element 3 and 6 and Appendix E for site specific habitat restoration and enhancement sites for both federal and private ownerships. Element 3 provides detail regarding the voluntary activities currently being implemented by The Timber Company. WQMP, Table 8, identifies each responsible entity by sub-watershed.

There are three mechanisms that are already in place to help assure that this water quality management plan will be implemented:

- Federal land management is guided by the Northwest Forest Plan which is implemented under the Aquatic Conservation Strategy.

In response to environmental concerns and litigation related to timber harvest and other operations on Federal Lands, the United States Forest Service (USFS) and the Bureau of Land Management (BLM) commissioned the Forest Ecosystem Management Assessment Team (FEMAT) to formulate and assess the consequences of management options. The assessment emphasizes producing management alternatives that comply with existing laws and maintaining the highest contribution of economic and social well being. The "backbone" of ecosystem management is recognized as constructing a network of late-successional forests and an interim and long-term scheme that protects aquatic and associated riparian habitats adequate to provide for *threatened species* and *at risk species*. Biological objectives of the Northwest Forest Plan include assuring adequate habitat on Federal lands to aid the "recovery" of late-successional forest habitat-associated species listed as threatened under the Endangered Species Act and preventing species from being listed under the Endangered Species Act.

- The state Forest Practices Act (FPA), implemented by the Department of Forestry, regulates forest activities. An interdepartmental review of the FPA will provide the assurance that standards will be met. The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on nonfederal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMP's for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness.

  The Oregon Forest Practices Act (FPA, 1994) contains regulatory provisions that include the following objectives: classify and protect water resources, reduce the impacts of clearcut harvesting, maintain soil and site productivity, ensure successful reforestation, reduce forest management impacts to anadromous fish, conserve and protect water quality and maintain fish and wildlife habitat, develop cooperative monitoring agreements, foster public participation, identify stream restoration projects, recognize the value of biodiversity and monitor/regulate the application of chemicals. Oregon's Department of Forestry (ODF) has adopted Forest Practice Administrative Rules (1997) that clearly define allowable actions on State, County and private forestlands. Forest Practice Administrative Rules allow revisions and adjustments to the regulatory parameters it contains. Several revisions have been made in previous years and it is expected that the ODF, in conjunction with DEQ, will continue to monitor the success of the Forest Practice Administrative Rules. In addition, monitoring activities identified in the accompanying ***WQMP Element 7*** will help determine if management actions are sufficiently protective to meet effective shade allocations set by this TMDL and make appropriate revisions that address water quality concerns.

- There are also many voluntary, non-regulatory, watershed improvement programs (activities) that are already in place and are helping to address the water quality concerns in upper South Fork Coquille Subbasin. Both technical expertise and funding are provided through these integrated programs. Examples of activities promoted and accomplished through these programs include: riparian enhancement, relocating legacy roads that may be detrimental to water quality, replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems. These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues.

  The State of Oregon has formed a partnership between Federal and State agencies, local groups and grassroots organizations, that recognizes the attributes of aquatic health and their connection to the health of salmonid populations. The Oregon Plan considers the condition of salmonids as a critical indicator of ecosystems (CSRI, 1997). The decline of salmonid populations has been linked to impoverished ecosystem form and function. Clearly stated, the Oregon Plan has committed the State of Oregon to the following obligations: an ecosystem approach that requires consideration of the full range of attributes of aquatic health, focuses on reversing factors for decline by meeting objectives that address these factors, develops adaptive management and a comprehensive monitoring strategy, and relies on citizens and constituent groups in all parts of the restoration process.

The intent of the Oregon Plan is to conserve and restore functional elements of the ecosystem that supports fish, wildlife and people. In essence, the Oregon Plan is distinctly different from the traditional agency approach, and instead, depends on sustaining a local-state-federal partnership. Specifically, the Oregon Plan is designed to build on existing State and Federal water quality programs, namely: Coastal Zone Nonpoint Pollution Control Programs, the Northwest Forest Plan, Oregon's Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's Total Maximum Daily Load Program.

Adaptive Management

The upper South Fork Coquille Subbasin TMDL/WQMP is intended to be adaptive. This plan allows for future changes in loading capacities and surrogate measures (allocations) in the event that scientifically valid reasons demand alterations. It is important to recognize the continual study and progression of understanding of water quality parameters addressed in this TMDL/WQMP (stream temperature, habitat, and flow).

The upper South Fork Coquille Subbasin ***WQMP addresses future monitoring plans in Element 7***.

In addition, both ODF and ODEQ will continue to work with partners to monitor TMDL implementation and the effectiveness thereof. In the event that data generated through subsequent monitoring efforts indicate that changes are warranted in this TMDL or WQMP, these changes will be made by Oregon DEQ, USFS, The Timber Company, and Oregon Department of Forestry.

Establishing TMDL's employs a variety of analytical techniques. Some analytical techniques are widely used and applied in evaluation of source loading and determination of the impacts on waterbodies. For certain pollutants, such as heat, the methods used are newer or in development. The selection of analysis techniques is based on scientific rationale coupled with interpretation of observed data. Concerns regarding the appropriateness and scientific integrity of the analysis have been defined and the approach for verifying the analysis through monitoring and implementation addressed. Without the benefit of long term experience and testing of the methods used to derive TMDL's, the potential for the estimate to require refinement is high.

A TMDL and margin of safety, which is reasonable and results in an overall allocation, represents 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.

9. PUBLIC PARTICIPATION

During development and in draft this assessment and subsequent management plan have been widely presented in Coos County and the draft document has been made available during development for input and discussion by resource as well as private entities.

Public participation is also addressed in Element 8 of the WQMP.

A responsiveness summary document will be prepared by DEQ in reply to comments received at the public hearing and written comments received within the comment period.

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