Appendix D

Bear Creek Watershed
Riparian Shade Assessment

Prepared by
Oregon Department of Environmental Quality

TMDL ASSESSMENT REPORT:
Riparian Shade

BEAR CREEK, OR
Rogue River Basin
Middle Rogue River Sub-Basin

Oregon Department of Environmental Quality

Coos Bay / Medford Offices

Rogue River National Forest
Star/Ashland Ranger District

May 9, 2000

Bear Creek Watershed – Overview	
Hydrologic Unit Code (Identification)	1710030801
Watershed Area / Ownership	Total: 253,440 acres Non-Fed. Ownership: 191,740 ac. (75.7%) BLM Ownership: 40,000 ac. (15.8%) USFS Ownership: 21,700 ac. (8.5%)
Stream Miles Assessed	Total: 283.2 miles Non-Fed. Ownership: 219.4 mi. (77.5%) BLM Ownership: 17.8 mi. (6.3%) USFS Ownership: 46.0 mi. (16.2%)
303(d) Listed Parameters	Temperature, Bacteria, Flow Modification, Habitat Modification
Key Resources and Uses (Bear Creek Mainstem and tributaries)	Salmonid, consumptive use (domestic, agricultural, industrial), recreation, aesthetic
Known Impacts	Urban and transportation infrastructures, residential and business structures, water withdrawals, agriculture, timber harvests and roads, sand and gravel mining.

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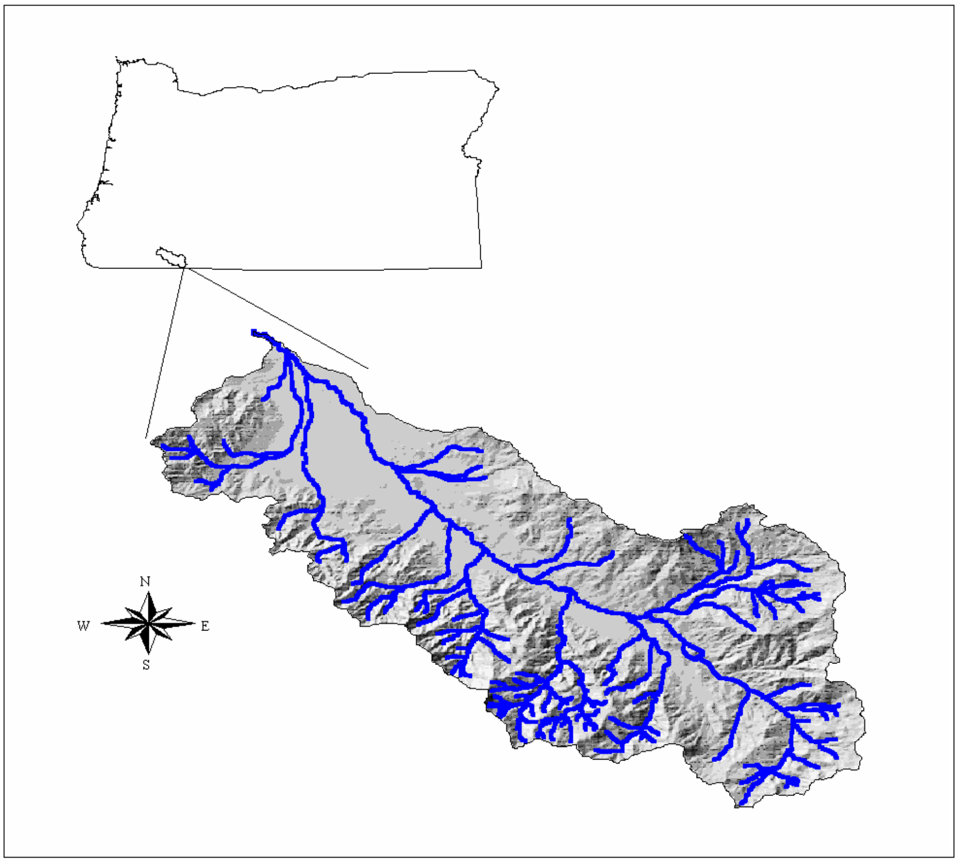

Figure 1. Location of the Bear Creek watershed and assessed stream network.

Legend of Terms, Abbreviations, and Acronyms

General

BLM – Bureau of Land Management
BTU– British Thermal Unit
CFF – cartographic feature file (USFS source)
cfs– cubic feet per second
DEQ– Department of Environmental Quality
DLG– digital line graph (USGS source)
DOQ – digital orthophoto quad (USGS source)
FPA– Forest Practices Act
LCDC – Land Conservation and Development Department
NMFS– National Marine Fisheries Service
OAR– Oregon Administrative Rule
ODF– Oregon Department of Forestry
OWEB – Oregon Watershed Enhancement Board
TMDL– Total Maximum Daily Load
Qa– average annual discharge (stream flow)
RVCOG – Rogue Valley Council of Governments
USFS– United States Forest Service
USGS– United States Geologic Service
WSC– Watershed Council

Assessment Parameter Definitions

Stream Name – name of primary stream or location of named tributary confluence.
DEQName – alphanumeric code: stream name (3 letters); reach #; special condition indicator (i.e. **e/w** = east/west; **p** = lake, pond, or impoundment). NOTE: unnamed tributaries are indicated by a decimal number following the reach number where it enters (e.g. if a tributary enters reach Wag4, it would be labeled Wag4.1, Wag4.2, etc.).
Overhang % – percent vegetative cover when the sun is directly overhead on the stream.
Active Channel – bankfull channel width.
Reach Length – linear stream distance.
Tree Height – average height of the primary shade producing trees or vegetation.
Terrain Slope – terrain slope from the active channel edge to the riparian shade vegetation.
Aspect Class – **0** = N-S; **45** = NE-SW; **-45** = NW-SE; **90** = E-W.
Tree-to-Channel Dist. – horizontal distance from the bankfull edge to base of riparian vegetation.
Shade Density – percent shade quality or the effectiveness of vegetation to block sunlight.
Stream Class

1998 ODF FPA definitions

L = large (Q_a >= 10 cfs); **M** = medium (2 cfs < Q_a < 10 cfs); **S** = small (Q_a < 2 cfs)

F = fish bearing; **D** = domestic use; **N** = neither F or D designation **L** = Large Lake (> 8 ac.); **OL** = Other Lake (_ 8 ac.)

Northwest Forest Plan definitions

F = fish bearing; **NF** = non-fish bearing;

Land Use

URB – Urban infrastructure and facilities
PF – Private Forestry
AG – irrigated or cultivated agricultural lands
RS – Private Resource Lands (non-cultivated agriculture, mining, county)
NR – Private Non-Resource Lands (i.e. rural residential)
MIX – mixed private land uses
CITY – City lands (specifically, City of Ashland)
BLM – Bureau of Land Management: Forest; Mixed; Non-Forest Lands
FS – United States Forest Service
ST – State of Oregon

Imperv. Surface – presence/absence of a non-removable impervious surface (i.e. paved road) that would inhibit the growth of riparian vegetation within 100 feet of the stream.

Irrigation Flow – known or observable diversions or points of return flow.

Stream Order – numeric ranking system of relative stream size (1st order stream are usually intermittent; stream ordered increases at the junction of two like ordered streams; base map is standard USGS 1:24,000 topographic).

Rosgen Level 1 Channel – stream channel classification based on channel slope, sinuosity, valley type, and stream pattern and form.

OWEB Channel Confinement – Oregon Watershed Enhancement Board classification protocols.

U – Unconfined; floodplain width > 4X bankfull width
M – Moderate Confinement; floodplain width 4X > bankfull width > 2X floodplain width
C – Confined; floodplain width < 2X bankfull width

Bank Stability – **Y** = vegetated banks, no evidence of erosion or mass wasting. **N** = no vegetation present; erosion or channel widening evident.

Buffer Width – averaged horizontal width of riparian vegetation (forested stands).

Percent of Reach – percent of reach length with described buffer.

Existing Veg. Comp. – existing riparian vegetation composition.

HB – herbaceous
MD – mixed deciduous stand
MC – mixed conifer stand
MD/HB – mixed deciduous and herbaceous
MD/C – mixed deciduous/conifer stand; deciduous dominant
MC/D – mixed deciduous/conifer stand; conifer dominant
TF – true fir
Wtlnd – wetland species

Age - age of dominant riparian trees based on average stand height and forest growth models. **Note**: if current shade density is 10% or less, then current age is set to 0.

Existing % Shade: Curve – percent shade from modeled shade curve value based on current tree height, active channel width, and shade density.

Wted Shade – reach weighted shade for a named stream.

Future Veg. Comp. – projected riparian vegetation based on current species composition.

HB – herbaceous
MD – mixed deciduous stand
MC – mixed conifer stand
MD/C – mixed deciduous/conifer stand; deciduous dominant
MC/D – mixed deciduous/conifer stand; conifer dominant

TF – true fir
Wtlnd – wetland species
Fut. Veg. Height – site potential tree height based on forest growth models.
Future Density – assumed potential shade density of riparian vegetation based on management of the stand for optimal tree growth and shade values.
Future % Shade: Curve – potential percent shade from modeled shade curves based on site potential tree height, active channel width, and shade density.
Delta Shade – (future shade) – (existing shade)
Recovery Time – years to site potential tree height from forest growth models given current tree heights.

Photo Interpretation, Mapping, and Conditions Assessment

Aerial photo interpretation and mapping was performed using BLM supplied 1996 color air photos at 1:12,000 scale, 7½' USGS quadrangle maps, and ODF stream classification maps. Streams and tributaries were included in the assessment if they were: 1) on the state's 303(d) list (for temperature); 2) the tributary area is 5% or greater of the watershed area above its confluence with the receiving stream; 3) fish-bearing status as per ODF stream classification maps and interim protocols; and/or 4) perennial stream flow. Note: tributary streams that are listed as intermittent on the USGS quadrangles or have an area less than 5% may have been included in this assessment if they cross non-federal lands to get a comprehensive overview of the existing conditions.

Reach breaks were established using the following criteria: 1) confluence of perennial streams; 2) change in ODF stream classification; 3) ownership boundaries as identified by the Medford District BLM "Recreation Map"; 4) significant changes in terrain slope or valley type; 5) change in aspect class; 6) change in riparian vegetation. Each reach was given a unique alphanumeric identification using (generally) the first three letters of the stream name followed by a number. Reaches were numbered sequentially from mouth to headwaters. Reach breaks were manuscripted on hard copy 7½' USGS quadrangles and transferred onto a GIS streams layer. The GIS streams layer was developed from an existing 1:24k BLM hydrography layer compiled from DLG and CFF files of the basin's hydrography.

The riparian assessment consisted of interpretation or measurement of shade parameters, riparian vegetation, and channel conditions. These values were taken from color aerial photos, USGS quadrangle maps, or GIS 1:24k streams layer (Table 1).

Table 1. Assessment Parameters.

Assessment Parameter	Resolution	Comments
Percent Overhang	10%	Photo estimated
Percent Shade Density	10%	Photo estimated; if current riparian trees have SD < 10%, then SD = 0 %
Terrain Slope	10%	Photo or map estimated
Aspect Class	60 deg.	Map; 229-29; 30-60/120-150; 61-119 deg.
Tree-to-Channel Distance	5 ft.	Photo estimated / measured
Tree Height	20 ft.	Average of primary shade vegetation
Width – Active Channel	5 ft.	Photo estimated / measured
Reach Length	100 ft.	GIS calculated
Buffer Width	10 ft.	Fed. = 300' max; Non-fed. = 100' max
Percent of Reach	10%	
Vegetation Composition		Deciduous, Conifer, Herbaceous
Stream Order (Strahler)		USGS 7½' quadrangles
Valley Slope	0.1	Slope gradient / Valley length (map)
Channel Sinuosity	0.1	Stream length / Valley length (photo)
Stream Slope	0.001	Valley slope / Sinuosity
Rosgen Channel – Level 1		Stream slope and photo interpreted
OWEB Channel Confinement		Photo or map estimated
Bank Stability		Photo estimated (Yes / No)
Stream Class		Size and classification
Land Use Class*		URB, PF, AG, RS, NR, MIX, CITY, ST, BLM, FS
Impervious Surface		Affecting riparian vegetation (Yes / No)
Stream Diversions		Known or observable on photo (In / Out)

<u>* Land Use Class</u>
URB – Urban infrastructure and facilitates
PF – Private Forestry
AG – irrigated or cultivated agricultural lands
RS – Private Resource Lands (non-cultivated agriculture, mining, county)
NR – Private Non-Resource Lands (i.e. rural residential)
MIX – mixed private land uses
CITY – City lands (specifically, City of Ashland)
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Several reaches of Bear Creek are depicted with a double line stream (i.e. both channel banks) on the GIS stream layer due to the channel size. If the assessment did not split the reach into east-west banks then the east bank stream arc is used to display habitat values. Where stream reaches were split into east-west banks for assessment purposes and the stream has only a single arc in GIS (Table 2), then the two banks were averaged for display purposes. For example, if a west bank had no shading vegetation while the east bank had 60% shade, it would be displayed as 30% shade for the reach. Reach specific assessment data may be referenced in Appendix D.

Table 2. East-West stream reaches averaged for GIS mapping.

Reach ID	Reason for E / W division
Brc34; Mye1	Vegetation
Brc22, 23, 24, 29, 31, 32, 35	Land use

In January of 1997 a large flood impacted the Bear Creek watershed and resulted in damage to channel banks and riparian vegetation. Post-flood air photos were taken in April 1998 and large-scale DOQs from these photos were made available by RVCOG. A detailed assessment of flood impacts was made along the main stem of Bear Creek comparing the post-flood DOQs to pre-flood aerial photos. Impacts to stream side vegetation and channel banks were noted and integrated into the riparian assessment.

Field Verification

Field verification (ground truthing) was conducted at 14 sites (Appendix B) during the summer of 1999. Six sites were not included in verification since the location of the field crew could not be absolutely identified on the aerial photos. Thus, a direct comparison between field measured values and photo-interpreted values could not be done with any confidence.

Field measurements were conducted using standard DEQ procedures and protocols for Shadow model ground truthing. Ground truthing reaches are 200 feet in length with the shade values assessed for only this length. Sampling is conducted at three transects (bottom, middle, and top) along the 200 feet reach. For active channel widths less than 25 feet, one solar pathfinder measurement is taken at center channel. For channels greater than 25 feet, three pathfinder measurements are taken across the channel at 25 percent intervals of the active channel width. A reach value for each parameter is computed by averaging all measurements taken. Field measurements are compared to photo-interpreted values and adjustments made to existing conditions if indicated.

Problem Description and TMDL

1998 303(d) Listing

Location	Parameter / Season	Listed Segment
Baldy Creek	Temperature / summer	Mouth to headwaters
Bear Creek	Temperature / summer	Mouth to Neil Creek
Butler Creek	Temperature / summer	Mouth to headwaters
Carter Creek	Temperature / summer	Mouth to headwaters
Coleman Creek	Temperature / summer	Mouth to headwaters
Emigrant Creek	Temperature / summer	Mouth to Emigrant Reservoir
Emigrant Creek	Temperature / summer	Emigrant Res. to Green Mt. Ck
Griffin Creek	Temperature / summer	Mouth to headwaters

Location	Parameter / Season	Listed Segment
Jackson Creek	Temperature / summer	Mouth to headwaters
Larson Creek	Temperature / summer	Mouth to headwaters
Myer Creek	Temperature / summer	Mouth to headwaters
Neil Creek	Temperature / summer	Mouth to I-5
Tyler Creek	Temperature / summer	Mouth to headwaters
Wagner Creek	Temperature / summer	Horn Gulch to Headwaters
Walker Creek (Ashland area)	Temperature / summer	Mouth to headwaters

Beneficial Uses by Stream Location in the Rogue Basin

Beneficial Uses	Rogue River Estuary & Adjacent Marine Waters	Rogue River Mainstem from Estuary to Lost Creek Dam	Rogue River Mainstem above Lost Creek Dam & Tributaries	**Bear Creek Main Stem**	**All Other Tributaries to Rogue River & Bear Creek**
Public Domestic Water Supply[1]		X	X	*	**X**
Private Domestic Water Supply[1]		X	X		**X**
Irrigation	X	X	X	**X**	**X**
Livestock Watering		X	X	**X**	**X**
Anadromous Fish Passage	X	X	X	**X**	**X**
Salmonid Fish Rearing	X	X	X	**X**	**X**
Salmonid Fish Spawning		X	X	**X**	**X**
Resident 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**
Commercial Navigation & Transportation	X	X	X		

* Designation for this use is presently under study
1 With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards

Water Quality Standards & Criteria of Concern

The water quality standard of concern (in this assessment) is temperature. The temperature standard for the Rogue Basin tributary streams is defined in OAR 340-41-362, “The rolling seven (7) day average of the daily maximum shall not exceed… 64 deg. F (17.8 deg. C)”.

Bear, Butler, Emigrant, Griffin, Jackson, Larson, Myer, Neil, and Walker Creeks were placed on the State of Oregon 1996 303(d) list for failing to meet this standard. Baldy, Carter, Coleman, Tyler, and Wagner Creeks were 1998 additions to the State of Oregon 303(d) list for failing to meet this standard.

The beneficial uses affected by high summer stream temperatures on these streams include: Resident Fish & Aquatic Life and Salmonid Fish Spawning and Rearing. Fish use, distributions, and habitat requirements are documented in the Bear Creek Watershed Assessment and Action Plan (Bear Creek WSC, May, 1995; pp. 69-78).

Pollution Sources

Impacts to the stream channel and riparian vegetation include: urbanization and urban infrastructures; agricultural activity; suburban and rural residential developments; water withdrawals; timber harvests; active and legacy aggregate mines; local and forest access roads; and federal, state, and county highways. Impacts that are more specific to federally managed lands included: timber harvests and roads; mining activity; and a few remnant homesteads or residential inholdings.

The degree of impact ranges from subtle to severe with potential recovery ranging from full to none. For example, a small, stand-thinning harvest can regain it's shade density within a relatively short time frame while the impact to channel geometry and riparian vegetation from the Interstate 5 corridor and urbanization are essentially permanent. Reach specific disturbances to riparian zones (100 ft.) are listed in the assessment tables (Appendix D).

Valley Bottom

Riparian conditions across Bear Creek's valley bottom (including tributary streams up to the foothills) vary from excellent (small percentage) to devoid of any large woody vegetation (i.e. trees). The majority of the system is in poor to fair condition. Riparian stands have generally moderate shade density and buffer widths less than 25 feet. There are however, pockets of dense riparian forest stands along agricultural/orchard lands that indicates a potential to manage a riparian forest stand for high shade density while coexisting with agricultural production.

Much of the stream channels are incised and disconnected from the floodplain and occasionally exhibit indications of bank instability. However, because of local land use significant bank erosion and subsequent channel widening is unlikely to develop. This results in Rosgen F and G type channels being restricted from evolving into their predicted B, C, or E type channels.

Bear Creek: Mouth to Medford

The stream along this section is a wide, entrenched system with very low sinuosity for what should be expected. It is generally a single thread channel with a few limited reaches where Rosgen Da type channel classification is possible (i.e. multi-thread, anastomosed channel). The stream is generally disconnected from its floodplain; stream banks have been eroded from the January 1997 flood event; large bar deposits are newly formed after the flood; and overall channel widths are ~20 feet wider than pre-flood widths.

Bear Creek: Medford to Talent

The stream along this section also has less sinuosity and channel complexity than should be expected. The channel corridor alternates between rural, agricultural, and urban-type land use impacts to the riparian zone and has several low-head dams and backwaters areas associated with irrigation diversions. Flood impacts are much more limited than below the city of Central Point, but have reduced riparian vegetation and increased channel widths in some locations. Increased sediment loading from bank erosion is evident from newly formed transverse and point bar development.

Bear Creek: Talent to Walker Creek Confluence
The stream along this section is regaining a degree of sinuosity and channel complexity. There is some connectivity with the floodplain occurring although riparian zones impacts from rural, agricultural, and urban land uses remain. Flood impacts to stream banks and riparian vegetation is much less while the overall channel width is decreasing and more vegetative overhang is present.

Urbanization Impacts on Channel Geometry
Urbanization impacts a watershed's hydrologic form and function by increasing impervious surface area, increasing the water routing efficiency of the system, increasing sediment inputs, and decreasing stream flows from water withdrawals. These impacts usually result in decreased drainage densities, higher peak discharge and flood levels over shorter periods (i.e. a steeper and shorter hydrograph), increased channel cross-sectional area, and a decreased annual discharge available to transport sediment.

Enlargement of cross-sectional area following urban development is a result of increased channel depth or width or both resulting from increased flood magnitudes and frequencies. Increased sediment loads further exacerbate these changes to channel geometry. Regional curves relating basin area to channel geometry can be used to make a rough determination of the magnitude of channel change (Dunne and Leopold, 1978. Water in Environmental Planning. W.H. Freeman and Comp., 891 pp.). A regional curve relating bankfull channel width to basin area is being developed for use in the Rogue Basin east of the coastal range crest (Appendix A). This curve is a rough start and should be further refined with additional data and analysis. However, based on available data, Bear Creek at its mouth is predicted to have a bankfull channel width roughly 100 feet given a drainage area of approximately 400 mi^2. Additional data and improvements to the regional curve may indicate that the actual channel width for the lower reaches of Bear Creek should be even less than 100 feet

Table 3: Summary of 303(d) listed stream segments.

303(d) Listed Stream Segments	Reach Length (ft)	Existing Percent Shade: Reach Weighted Average	Site Potential Percent Shade: Reach Weighted Average	Change in Percent Shade: Reach Weighted Average	Years to Recovery: Reach Weighted Average
Bear Ck	140,758	15	54	39	80
Coleman Ck	33,075	67	89	21	70
Griffin Ck	91,715	47	85	38	71
Jackson Ck	122,477	46	88	42	73
Wagner Ck	28,874	80	91	12	35
Larson Ck	34,655	34	82	47	77
Myer Ck	25,351	40	83	42	75
Butler Ck	21,800	21	84	63	75
Neil Ck	74,869	66	84	19	62
Emigrant Ck[1]	84,238	35	76	41	69
Carter Ck	25,580	60	86	26	77
Tyler Ck	13,486	64	92	28	77
Baldy Ck	19,897	72	93	21	76
Walker Ck	224,685	49	86	37	78
	941,460	**43**	**79**	**36**	**72**

1. Emigrant Reservoir is not included.

Table 4: Summary of assessed stream systems.

Stream System	Reach Length (ft)	Existing Percent Shade: Reach Weighted Average	Site Potential Percent Shade: Reach Weighted Average	Change in Percent Shade: Reach Weighted Average	Years to Recovery: Reach Weighted Average
Bear Ck	140,758	15	54	39	80
Jackson Ck	122,477	46	88	42	73
Griffin Ck	91,715	47	85	38	71
Coleman Ck	33,075	67	89	21	70
Anderson Ck	65,405	58	90	32	68
Wagner Ck	143,810	70	91	21	56
Ashland Ck[1]	229,508	91	94	3	30
Lazy Ck	22,939	26	82	56	73
Larson Ck	34,655	34	82	47	77
Myer Ck	25,351	40	83	42	75
Butler Ck	21,800	21	84	63	75
Neil Ck	139,593	71	88	17	59
Emigrant Ck[1]	199,561	54	85	31	74
Walker Ck	224,685	49	86	37	78
	1,495,332	**55**	**84**	**29**	**66**

1. Emigrant Reservoir and Reeder Reservoir are not included.

TMDL Recovery

Goals

Element	**Goal**	**Passive Restoration**	**Active Restoration**
Temperature *Shade Component*	Achieve coolest water possible through achievement of potential shade values.	Allow riparian vegetation to grow up to reach target values. Follow LCDC Goal 5 recommendations for riparian management on private lands.	Bank stabilization where indicated. Prescriptions that increases growth rate and survival of riparian vegetation. Prescriptions to ensure long-term vegetation health.
Temperature *Channel Form Component*	Reduce channel width in lower Bear Creek to the 100-foot range. Maintain or improve Rosgen channel types that exist – types A, B, and C, focusing on width-to-depth ratios. Decrease bedload	Allow natural channel evolution to continue. Time required varies with channel type. Allow historic failures to revegetate. Follow Standards and Guidelines in the NW Forest Plan for Riparian	Review bank stability and manage towards decreasing bank erosion. Treat roads, esp. sites with diversion potentials. Maintain and improve road surfacing. Increase pipes to 100-yr flow size and/or provide for

Element	Goal	Passive Restoration	Active Restoration
	contribution to channels during large storm events.	Reserves and unstable lands on federally managed lands.	overtopping during floods.
Temperature Stream Flow Components: - Withdrawals - Hydrograph	Maintain optimum flows for fish life. Maintain minimum flows for fish passage.		Improve efficiency of withdrawal systems (ditch to pipe). Work with state Watermaster to identify and stop illegal diversions. Educate water users on effective use and conservation. Reduce road densities by decommissioning non-essential roads._ Eliminate clear-cut logging practices. Purchase/lease floodplain easements. Purchase/lease water rights with a focus on high consumptive use and old priority date. Enforce existing regulations, including monitoring.

Objectives

Element	Assessed Factors	Target Solar Load[1]	Contributing Factors	Change in Solar Load[2]	Management Measures
Temperature *Shade*	Percent Shade	546 BTU/ft²/day (79% shade[3])	Agriculture Rural / Urban Transportation Silviculture Mining	Decrease in current solar loading by 36%[3]	Establishment of riparian forest stands. Treatments to increase growth and long-term health of riparian vegetation.
Temperature *Channel Form Rosgen A, B, C*	W / D Ratio	1431BTU/ft²/day (45% shade[4])	Agriculture Urbanization Silviculture Mining Natural	Decrease in current solar loading by 39%[4]	Bank stabilization, where indicated. Agricultural buffer strips Urban and upland sediment abatement

Element	Assessed Factors	Target Solar Load[1]	Contributing Factors	Change in Solar Load[2]	Management Measures
			background		
<u>Temperature</u> *Stream Flow*	OR WRD water rights maps	Pending temperature modeling	Irrigation and domestic water withdrawals	Current conditions?	Education regarding water conservation Enforcement of water rights

1 – Target Solar Load (Loading Capacity); based on 2,601 BTU/ft²/day (maximum July insolation at Medford, OR; collector: horizontal flat-plat; +/- 9% uncertainty)
<u>Calculation</u>: [(1.0 - decimal percent shade) * 2,601 BTU/ft²/day]

2 – Change in Solar Load (Load Allocation); (Target Shade) - (Existing Shade); refer to TMDL Allocation Tables, page 10.
3 – Reach weighted value for the Bear Creek 5th field watershed. Includes the effect of reduced channel widths for Bear Creek.

4 – Calculated values for only Bear Creek reaches Brc4, 7, 8, and 9 with active channel widths of 100 feet and Brc20, 34, and 52 with active channel widths of 60 feet. These values also assume a site potential vegetative community composition.

<u>TMDL Allocations</u>

Solar Loading[1] / TMDL Bear Creek (main stem only)			
Target Shade	**54%**	Target Solar Load	**1,190 BTU/ft²/day**
Existing Shade	**15%**	Existing Solar Load / TMDL	**2,207 BTU/ft²/day**
Change in Shade	**39%**	Change in Solar Load	**- 1,017 BTU/ft²/day**

Solar Loading[1] / TMDL Jackson Creek			
Target Shade	**88%**	Target Solar Load	**308 BTU/ft²/day**
Existing Shade	**46%**	Existing Solar Load / TMDL	**1,404 BTU/ft²/day**
Change in Shade	**42%**	Change in Solar Load	**- 1,096 BTU/ft²/day**

Solar Loading[1] / TMDL Griffin Creek			
Target Shade	**85%**	Target Solar Load	**390 BTU/ft²/day**
Existing Shade	**47%**	Existing Solar Load / TMDL	**1,386 BTU/ft²/day**
Change in Shade	**38%**	Change in Solar Load	**- 995 BTU/ft²/day**

Solar Loading[1] / TMDL Lazy Creek			
Target Shade	**82%**	Target Solar Load	**469 BTU/ft²/day**
Existing Shade	**26%**	Existing Solar Load / TMDL	**1,921 BTU/ft²/day**
Change in Shade	**56%**	Change in Solar Load	**- 1,452 BTU/ft²/day**

Solar Loading[1] / TMDL Coleman Creek			
Target Shade	**89%**	Target Solar Load	**299 BTU/ft²/day**
Existing Shade	**67%**	Existing Solar Load / TMDL	**852 BTU/ft²/day**
Change in Shade	**21%**	Change in Solar Load	**- 553 BTU/ft²/day**

Solar Loading[1] / TMDL Wagner Creek			
Target Shade	**91%**	Target Solar Load	**232 BTU/ft²/day**
Existing Shade	**70%**	Existing Solar Load / TMDL	**790 BTU/ft²/day**
Change in Shade	**21%**	Change in Solar Load	**- 558 BTU/ft²/day**

Solar Loading[1] / TMDL Myer Creek			
Target Shade	**83%**	Target Solar Load	**454 BTU/ft²/day**
Existing Shade	**40%**	Existing Solar Load / TMDL	**1,554 BTU/ft²/day**
Change in Shade	**42%**	Change in Solar Load	**- 1,100 BTU/ft²/day**

Solar Loading[1] / TMDL Butler Creek			
Target Shade	**84%**	Target Solar Load	**417 BTU/ft²/day**
Existing Shade	**21%**	Existing Solar Load / TMDL	**2,064 BTU/ft²/day**
Change in Shade	**63%**	Change in Solar Load	**- 1,647 BTU/ft²/day**

Solar Loading[1] / TMDL Ashland Creek			
Target Shade	**94%**	Target Solar Load	**157 BTU/ft²/day**
Existing Shade	**91%**	Existing Solar Load / TMDL	**246 BTU/ft²/day**
Change in Shade	**3%**	Change in Solar Load	**- 89 BTU/ft²/day**

Solar Loading[1] / TMDL Neil Creek			
Target Shade	**88%**	Target Solar Load	**301 BTU/ft²/day**
Existing Shade	**71%**	Existing Solar Load / TMDL	**747 BTU/ft²/day**
Change in Shade	**17%**	Change in Solar Load	**- 446 BTU/ft²/day**

Solar Loading[1] / TMDL Walker Creek (Ashland area)			
Target Shade	**86%**	Target Solar Load	**364 BTU/ft²/day**
Existing Shade	**41%**	Existing Solar Load / TMDL	**1,339 BTU/ft²/day**
Change in Shade	**37%**	Change in Solar Load	**- 975 BTU/ft²/day**

Solar Loading[1] / TMDL Emigrant Creek			
Target Shade	**85%**	Target Solar Load	**393 BTU/ft²/day**
Existing Shade	**54%**	Existing Solar Load / TMDL	**1,194 BTU/ft²/day**
Change in Shade	**31%**	Change in Solar Load	**- 801 BTU/ft²/day**

1. based on 2,601 BTU/ft²/day (maximum July insolation at Medford, OR; collector: horizontal flat-plat; +/- 9% uncertain

NOTE: All values are reach-weighted averages for watershed indicated.

Margin of Safety

Riparian Assessment

A conservative assessment was used in the measurement of shade density and vegetation overhang. Shade density accounted for the composition and stocking level of the riparian vegetation with a maximum value of 80% (heavily stocked hardwood stand). Vegetation overhang was measured by estimating the percent of stream channel covered with vegetation. The highest overhang value recorded was 80%, even for closed canopy reaches.

Shade Curves

Shade is based on the earth-sun-terrain/vegetation relationship on August 1 for specified latitudes. The shade model Shadow was used to calculate percent shade based on three sets of average channel, terrain, and vegetation characteristics and three aspect classes. Shade tables (Appendix C) were broken into large streams and small streams with confined channels and valley streams with unconfined channels. Channel widths ranged from 30 to 120 feet and 5 to 25 feet for large and small streams respectively, and 10 to 120 feet for valley streams. Tree heights ranged from 20 to 180 feet in 20-foot intervals. Percent shade was calculated for each channel width - tree height combination with shade densities varied from 10% to 80%, at 10% steps. Base assumptions used for each shade table are listed in Table 3. Valley tables were used for Bear Creek (all reaches), Jackson Creek reaches 1-2, Griffin Creek reach 1, Coleman Creek reaches 1-8, Anderson Creek reach 1, Wagner Creek reach 1, and Lazy Creek reaches 1-7.

Table 5. Base assumptions for shade tables.

Shade Variable	Large Streams	Small Streams	Valley Streams
Vegetation Overhang	0%	0%	0%
Tree to Channel Slope	30%	50%	20%
Tree to Channel Distance	25 feet	10 feet	10 feet

Ashland Creek

The Ashland Creek watershed from the US Forest Service boundary to the headwaters used a set of shade curves (Appendix C) developed with the following averaged values:

Shade Variable	Upland Streams
Vegetation Overhang	50%
Tree to Channel Slope	30%
Tree to Channel Distance	5 ft

Future Conditions Modeling

Forest growth models were used to project growth rates and heights for the dominant riparian tree species. Growth models are constructed by species and delineated by site index (SI) or site class values that relate to growing conditions. Tree species in Bear Creek and associated site values are listed in Table 6.

Riparian corridors are assumed to be manage to reach their full site potential condition. Shade densities for site potential conditions were set at 70% for a conifer dominant, mixed old growth, and cottonwood dominant hardwood stands, and 80% for a mature hardwood dominant stand (non-cottonwood). Stand densities and recovery times (e.g. years to grow to site potential heights) assumes the existing vegetation will continue to grow through seral progressions to a late seral stage. Natural events such as floods or fires may alter the progression rate and achievement of late seral stand conditions.

Vegetation overhang is likely to increase in most cases as riparian stands grow and mature. The extent of this increase is difficult to project, but may exceed 90% on small headwater streams. Shade tables were constructed with an overhang of 0%, which is an extremely conservative assumption for site potential conditions.

Along Bear Creek's lower reaches where channel widths are larger than 100 feet, future conditions were modeled with a channel width of 100 feet. The recovery time that is required to regain channel width is not included in this assessment. The time needed to stabilize and rebuild stream banks and establish riparian trees within an existing bankfull channel is difficult to estimate with any certainty.

Table 6. Tree species and forest growth model site values.

Tree Species	Site Index	Site Class	Height	Years
Red Alder[1]	70		88	80
Cottonwood[2]		II	97	101
Douglas fir[3]	85		148	120
Ponderosa pine[3]	85		153	120

1 - Worthington, N.P., Johnson, F.A., Stoebler, G.R., and Lloyd, W.S., 1960. PNW Experiment Station Paper 36.
2 - Burns, R. M. and B. H. Honkala (1990). Silvics of North American Trees. Vol2, Hardwoods. Washington, D.C., U.S. Department of Agriculture. pp. 570-582.
3 - Hann, D.W., and Scrivani, J.A., 1987. Research Bulletin 59, Oregon St. Univ. Forest Research Lab. "Dominant-Height-Growth and Site Index Equations for Douglas-Fir and Ponderosa Pine in SW Oregon." pg. 7 equation, "Estimating Future Heights of Dominant Trees in Hypothetical Stands."