Appendix I
Water

This appendix provides supplemental material for the topics discussed within the chapters of this final environmental i mpact statement that are related to water resources and riparian areas on BLM-administrated lands.

In this appendix:

Water Planning Criteria

Analytical Question # 1

How does timber harvest affect peak flow estimates, under the alternatives, that exceed detection limits within the rain-dominated hydroregion?

Analytical Assumptions

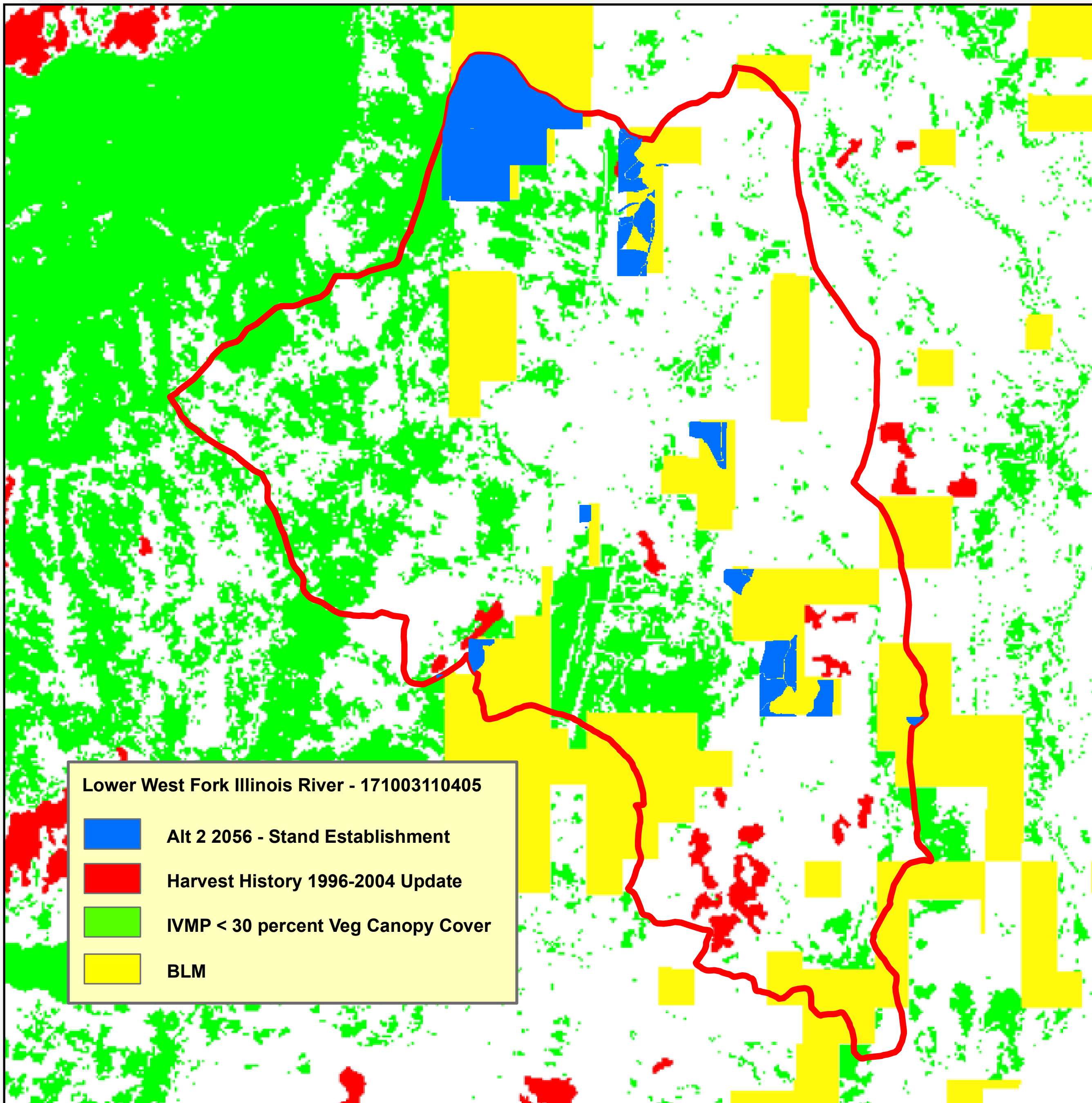
- The subwatershed level (USGS Sixth-field Hydrologic Unit Code (10,000 to 40,000 acres) will be used to report forest cover relationships for the susceptibility of peak flow increase.
- Hydroregions are a physical classification of landscapes based on the form of precipitation with elevation, as predominantly rain, rain and snow, or snow.
- Removal of forest basal area is used as a surrogate for reductions in leaf area in the rain-dominated hydroregion. The most consistent mechanism for producing peak flow changes is related to reduced evapotranspiration following harvest, resulting in higher soil moisture levels. Higher peak flows are seen during early fall storms, but the percent increase decreases rapidly with increasing event magnitude, and falls below detection levels at approximately a six year peak flow return interval runoff frequency. (Grant et al. 2008).
- The largest percent increases in peak flows are observed in 100 percent harvested watersheds in the rain-dominated hydroregion. The magnitude of peak flow increases represents the maximum potential increases for large canopy openings since the size of opening relates directly to the runoff processes (Grant et al. 2008).
- Within the rain-dominated hydroregion the effect of increased peakflow is roughly proportional to area cut (equivalent clearcut area). Patch size, stand age, or arrangement is not a factor in explaining greater flow volume or differences in timing, compared to the rain-on-snow dominated hydroregion (Harr and Coffin, 1992). Where variable reductions in basal area occur by thinning or partial cuts, the inter-relationships of forest tree size, stocking, distribution and age affect leaf area and evapotranspiration, but the effect on peak flow increase is less clear (Grant et al. 2008). Ziemer (1981, 1998) found a non-statistical increase (4%) in peak flow for 80-year-old conifer stands that were harvested where, 50% of the basal area was retained.
- Forest cover relationships on BLM-administered lands will use the 10-year projection derived data layers by alternative will be used as a surrogate to determine basal area removed or equivalent clearcut acreage, using the acres of the ecology description attributes of stand establishment. The stand establishment description includes total basal area removal, as well as forest stands where partial cuts are completed, leaving legacy trees in varying densities. A stand establishment forest may be up to 30 years in age where older trees are retained, and may be growing closed on some sites.
- Forest cover relationships on other lands (other federal, state and private) will use acres of less than 30% vegetative crown closure released from the 1996 Interagency Vegetation Mapping Project TM as a surrogate for removal of basal area or equivalent clearcut area. Any acre meeting this description is binned as basal area removed. Acres included are forest stands where the total basal area is removed as clearcuts and partial cuts with <30% canopy closure. There are variations of crown area on the IVMP datasets for a given timber stand species, age spacing, etc., when cross-walked with basal area removed for susceptibility of peak flow increase. The BLM looked at tree diameter/crown diameter; where ratios vary from 0.7 for mature trees to 2 for trees in young plantations. A normal forest density management treatment may remove 1/3 of the volume, ½ of the stem count, and result in 80-100 remaining trees per acre. For harvestable coniferous forest stands, vertical projections were made to determine the area of remaining crowns after this normal treatment. Stand summaries indicate that 40-50% canopy closure as a surrogate measure would

maintain 50% of the basal area which has been shown to have an inconsequential effect on peak flow increase. However, in some watersheds, there are large areas of low density unmanaged forest. These forests could not be reasonably separated in the analysis. This is because the GIS algorithms that process the IVMP satellite imagery raster (cell) datasets cannot distinguish between forest harvest and natural low density forest. The affected subwatersheds are more numerous in southern Oregon, particularly along ridgetops and sideslopes where higher fire frequency has occurred. Open forest also is present in some areas of tanoak forest or where open meadows are present. Refer to *Figure I-*1 (*Lower West Fork Illinois River low density forest)* and *Figure I-2* (*IVMP mapping of <30% canopy cover on other lands within Lower West Fork Illinois River*) for a visual comparison. Modeling trials revealed that the false identification increases as the canopy closure is increased. From these trial optimizations, the BLM chose to use the <30% canopy closure as a surrogate for basal area removed for partial cut forest stands.

- Forest cover relationships on other lands assumed that the relative proportion of basal area removed or equivalent clearcut area by subwatershed is the same for all planning time periods. This is because the future management of forest stands for these land ownerships is unknown.
- The analytical procedure is a screening process to determine probable subwatersheds at risk for peak flow enhancement from removal of basal area in the precipitation dominated hydroregion. The output changes, depending upon the forest harvest intensity, current conditions and spatial distribution of harvest units within subwatersheds.

Figure I-1. Lower West Fork Illinois River Low Density Forest

Figure I-2. IVMP Mapping Of <30 Percent Canopy Cover On Other Lands Within Lower West Fork Illinois River



Analytical Methodology and Technique

The technique relies on ARC GIS processes for analyzing spatial data. Logical and mathematical operations will be written as scripts, based on watershed analysis methodologies.

Step 1 –
Using the Hydroregions derived data layer (Planning Criteria #2 step 3), exclude any subwatersheds from further analysis that contain < 70% rain-dominated areas. Mask the area of the remaining subwatersheds that are not rain dominated. Build a new selected set labeled "Rain Dominated."

Step 2 –
For other lands, determine "Existing Condition Hydrologic Maturity" for forest vegetation by reclassing the 1996 classified Interagency Vegetation Mapping Project TM (IVMP) imagery. *Table I-1 (Vegetation hydrologic maturity assignment for IVMP data layer)* will be used to construct the derived data layer.

Step 3 –
Merge the "Current Condition Hydrologic Maturity" on other lands (step 2) with the rain-dominated subwatersheds selected set (step 1). Merge the BLM forest projections vegetation structural stages at 2006, 2016, 2026, 2056, and 2106 years, by alternative, with the rain-dominated subwatersheds selected set (step 1).

Step 4 –
For BLM-administered lands, calculate the acres of basal area removed or equivalent clearcut area by alternative and forest projection at 2006, 2016, 2026, 2056, and 2106 years. Include the stand establishment ecology polygons (acres), with the attribute stand establishment for each rain-dominated subwatershed.

Step 5 –
For other lands, calculate the acres of each rain-dominated subwatershed that is minimum hydrologic maturity (step #2, *Table I-1*).

Step 6 –
Sum the total basal area removed or equivalent clearcut area in acres, by each subwatershed, for the existing condition and each alternative and forest projection (steps 4 and 5). Calculate total subwatershed acres, and basal area removed as a percent of the total watershed acres.

Step 7 –
Conduct reference analysis. Replace the BLM forest projections data layer by alternative with the same attributes in step 4 with "no harvest" and "maximum harvest" on commercial forest lands projections.

Table I-1. Vegetation Hydrologic Maturity Assignment For IVMP Data Layer

IVMP Data Layer	Hydrologic Maturity
Harvest History	<10% crown closure, 1996-2004
Vegetation Canopy Cover	<30% total crown closure

Analytical Conclusions

Rank the precipitation dominated subwatersheds that exceed 29% basal area removed or equivalent clearcut area as sensitive for peak flow increase.

Data Needs

- Classified 1996 imagery from the Interagency Vegetation Mapping Project TM (IVMP), including new openings under 10 years of age, current to 2005. This will include the Vegetation Canopy Cover and Harvest History data layers.
- GIS-derived data layer of hydroregions.
- GIS-derived data layer of vegetation hydrologic maturity.
- Watershed GIS coverage (for determining area and subwatersheds)
- By alternative, GIS-derived spatial data layer of forest projection stand establishment in acres at 2006, 2016, 2026, 2056 and 2106 years.

Data Display

Figure showing subwatersheds with BLM-administered lands where basal area removed or equivalent clearcut area exceeds 29%, for the existing condition and with the application of each alternative's forest projections at 2006, 2016, 2026, 2056 and 2106 years.

Analytical Question # 2

How does timber harvest affect peak flow estimates, under the alternatives, that exceed detection limits within the rain-on-snow dominated hydroregion?

Analytical Assumptions

- Hydroregions are a physical classification of landscapes based on the form of precipitation with elevation, as predominantly rain, rain and snow, or snow. Rain-on- snow areas where shallow snow accumulations can come and go have been reported by Harr (1981, 1992) to be in the elevation range of 1200-3600 feet in western Oregon and from 2500 to 5000 feet in the southern Oregon Cascades (Lindell, pers.com.).
- The subwatershed level (USGS sixth-field Hydrologic Unit Code 10,000 to 40,000 acres) was chosen for the analysis, because it better approximates the BLM forest land pattern, and tributary streams are more sensitive to vegetation and runoff-related changes.
- Forest openings commonly receive greater snow accumulation (2 to 3 times more snow water equivalent) than adjacent forests (Harr 1992). These openings also receive greater wind speeds and twice the amount of heat during rain-on-snow events, which provides greater melt, compared to the mature forest (Harr 1981, 1992; Storck 1997). Regeneration harvest will provide additional melt contributions under rain-on-snow conditions (Harr 1981, Storck 1997).
- Elevated peakflow that can be measured in a managed experimental watershed when a rain-on-snow event occurs corresponds with a streamflow return period of 2 to 8 to years where pre-logging and post-logging regressions were significantly different (Harr 1992), and 1 to 6 years as reported by Grant et al. 2008.
- Basin characteristics regression analysis with gauged watersheds of long-term record is an appropriate method of describing peak flows of various exceedance probabilities for unregulated streams in ungauged watersheds. Harris and Hubbard (1979) flood frequency equations were chosen as reference points; because they cover the various hydrologic regions in the plan area and have long-term records (10-70 years). The base period of streamflow data collection for use in the analysis was prior to maximum forest conversion in many watersheds. Therefore the methodology would be more sensitive to the current intensity of forest management, because runoff at gauged sites

that was used in the equations was based on a greater proportion of hydrologically mature forest. The data set includes some rain-on-snow events including the 1964 flood.

- The 2-year, 24-hour precipitation intensity is assumed to coincide with the 2-year, 24-hour discharge.
- U.S. Army Corps of Engineers studies (USACE 1956, 1998) show that the principal melt component in a rain-on-snow event is convection/condensation melt. This component is far larger than long-wave and short-wave radiation melt, rain melt, and ground melt. In a typical USACE rain-on-snow example, convection/condensation melt accounts for 70 percent of daily snowmelt quantities. Ground wind speed, warm air temperatures and nearly equivalent dewpoint temperatures are the drivers in the convection/condensation melt term.
- For other lands, it is assumed that the percentage of basal area removed is the same for all planning time periods by subwatershed.
- This analytical procedure is viewed as a screening process to determine probable subwatersheds at risk for peak flow enhancement from rapid melt of shallow snowpacks, during heavy rainfall and windy weather. The output changes, depending upon forest harvest intensity, current conditions and spatial distribution of harvest units within subwatersheds, as well as climate, and elevation.

Analytical Methodology and Technique

The technique relies on ARC GIS GRID processes for analyzing spatial data. Logical and mathematical operations were written as scripts, based on watershed analysis methodologies. The analytical technique is an empirical approach patterned in part from the Washington State Department of Natural Resources Standard Methodology for Conducting Watershed Analysis,1997 (v. 4.0), Appendix C.

Step 1 -
Construct "Flood-Frequency Precipitation" data layer. Obtain precipitation frequency data for the 2-year 24-hour storm for the plan area (NOAA 1973) in raster format available online: [http://www.nws.noaa.gov/ohd/hdsc/noaaatlas2.htm]

Step 2 -
Merge the BLM watershed GIS theme with the "Flood-Frequency Precipitation" derived data layer at the subwatershed level.

Step 3 -
Determine "Hydroregions." Construct a derived data layer to include elevation bands of rain-dominated areas that are below the rain-on-snow zone; rain-on-snow zone (also called transitional) and snow-dominated zone that are above the rain-on-snow zone. District hydrologists will assign lower and upper elevation bounds for the rain-on-snow zone for all subwatersheds wholly or partly contained in the plan area, based on the following criteria:

Lower Bounds of the Rain-On-Snow Zone

Use National Resources Conservation Service SNOWTEL data for January 1 snow accumulation elevation (Greenburg and Welch 1998), and local hydrologist observation, which may vary from 1200-2500 feet.

Upper Bounds of the Rain-On-Snow Zone

Use regionally established upper limit from hydrologist observation or -literature or the onset of frozen soils, which may vary from 3600-5000 feet.

Step 4 -
Filter the "Hydroregions" derived data layer. Filter by subwatershed, and exclude any subwatersheds from further analysis that contain only rain areas or only permanent snow areas or <10% rain-on-snow (transitional) areas. Make a new derived data layer labeled "rain-on-snow" selected from the set.

Step 5 –
Using the rain-on-snow selected set, separate the subwatersheds by flood region (Harris and Hubbard 1979), online: [http://water.usgs.gov/software/nff_ manual/or/oregon_AFrame_3.gif]

Step 6 -
Calculate the 2-year 24-hour stream flow, and the 5-year 24-hour stream flow, using the USGS basin characteristics regression analysis method (Harris and Hubbard 1979) and GIS scripts.

2-Year 24-Hour Streamflow
Coast Region: $Q_{0.5}=4.59A^{0.96}(ST+1)^{-0.45}I^{1.91}$

Willamette Region: $Q_{0.5}=8.70A^{0.87}I^{1.71}$

Rogue-Umpqua Region: $Q_{0.5}=24.2A^{0.86}(ST+1)^{-1.16}I^{1.15}$

High Cascades: $Q_{0.5}=4.75A^{0.90}(ST+1)^{-0.62}(101-F)^{0.11}I^{1.17}$

where:
$Q_{0.5}$= discharge in cubic feet per second (CFS) for a 2-year 24-hour recurrence interval event:
A = drainage area in square miles
ST = area of lakes and ponds in percent
F = forest cover in percent
I = 2-year 24-hour precipitation intensity in inches

5-Year 24-Hour Streamflow
Coast Region: $Q_{0.2}=6.27A^{0.95}(ST+1)^{-0.45}I^{1.95}$

Willamette Region: $Q_{0.2}=15.6A^{0.88}I^{1.55}$

Rogue-Umpqua Region: $Q_{0.2}=36A^{0.88}(ST+1)^{-1.25}I^{1.15}$

High Cascades: $Q_{0.2}=8.36A^{0.86}(ST+1)^{-0.81}(101-F)^{0.08}I^{1.30}$

where:

$Q_{0.2}$= discharge in cubic feet per second (CFS) for a 5-year 24-hour recurrence interval event,
A = drainage area in square miles
ST = area of lakes and ponds in percent
F = forest cover in percent
I = 2-year 24-hour precipitation intensity in inches

Area of lakes and ponds include natural lakes, ponds, and impoundments.
Forest cover is the watershed area greater than 10% forest cover, and is the hydrologic maturity cover classes A and B (step 7).

Step 7 –
Determine "Existing Condition Hydrologic Maturity" for forest vegetation, by reclassing the 1996 classified Interagency Vegetation Mapping Project TM (IVMP) imagery. The Vegetation Canopy Cover and Harvest History (from 1996 to 2004) datasets will be used. The table below will be used to construct the derived data layer.

Step 8 -
Merge the "Existing Condition Hydrologic Maturity" with the "Rain-on-Snow" subwatersheds selected set (step 4).

Table I-2. Vegetation Hydrologic Maturity Assignment To Land Cover Class

	Hydrologic Maturity	Land Cover Classes
A	Hydrologically Mature	>70% total crown closure AND <75% of the crown in hardwoods or shrubs
B	Intermediate Hydrologic Maturity	10%-70% total crown closure AND <75% of the crown in hardwoods or shrubs
C	Minimum Hydrologic Maturity	<10% total crown closure AND/OR >75% of the crown in hardwoods or shrubs
D	Non-Forested	Agricultural and Grazing Lands Open Water Lakes, Ponds, Reservoirs Inundated Wetlands Other naturally occurring open areas

Source: Department of Natural Resources, Hydrologic Change Module

Step 9 -
Estimate snow depth and snow water equivalent to create an "Estimated Snow-water Equivalent" derived data layer.

Obtain the Topographic Data theme for Rain-on-Snow" subwatersheds selected set (step 4) and build a raster derived data layer.

Solve the following two snow water equivalent (SWE) equations for the topographic data theme by writing scripts (Greenburg and Welch 1998):

Northwest Oregon SWE =0.009*Elevation-21.66 *R

Southwest Oregon SWE =0.006*Elevation-19.53*R

where: SWE = February 1 snow-water equivalent in inches.
Elevation = elevation in feet.
R = snowwater equivalent ratio to adjust for cover types

The division between northwest and southwest Oregon regions (for equations) will be determined by an eastward line following the southern edge of the Siuslaw sub-basin in the Coast Range to the southern edge of the Willamette sub-basin through the Willamette Valley and the Cascades. The line is formed by watersheds:

Lower Siuslaw River	1710020608
Upper Siuslaw River	1710020601
Upper Coast Fork Willamette	1709000203
Row River	709000201
Hills Creek Reservoir	1709000105
Upper Middle Fork Willamette	1709000101

Snow water equivalent (SWE) values calculated are assumed to represent snow accumulation in hydrologically mature forests; these must be modified to account for variations in accumulation between different land use/cover types.

Populate the two snow water equivalent scripts with the snow-water equivalent ratios (R) for the existing condition for the northwest and southwest Oregon areas using classified IVMP data (Step 7), in *Table I-3* (*Vegetation hydrologic maturity and snow water equivalent ratios*).

Step 10 -
Determine One-Day Snowmelt for a 24-hour design storm for the existing condition by writing scripts. This procedure uses equations from the U.S. Army Corp of Engineers (1998).

For heavily forested or partly forested areas (step 7 land cover classes A and B):

$$M = (0.074 + 0.007P_r)(T_a - 32) + 0.05$$

For minimum forest or open areas (step 7 land cover classes C and D):

$$M = (0.029 + 0.0084kv + 0.007P_r)(T_a - 32) + 0.09$$

<u>*where:*</u>
M = snowmelt, in/day
v = wind velocity, miles per hour
P_r = rate of precipitation, in./day
T_a = temperature of saturated air, at 10-feet level, °F
k = basin wind coefficient. Use 0.4 for heavily to partly forested areas (hydrologic maturity land cover classes A, and B), and 0.9 for open areas (hydrologic maturity land cover class C and D).

Calculate snowmelt in each hydrologic maturity land cover cell for the existing condition. If the calculated snowmelt (M) for a given scenario exceeds the estimated snow equivalent (SWE), set M = SWE; also, if T_a is ≤ 32 °F, M = 0.

Temperature

Storm temperature varies primarily with elevation. Determine the average storm temperature (Ta °F) for each cell area based on generalized regional lapse-rate equations:

Western Oregon = 50 - (.0033 * E)

<u>*where:*</u>
E = elevation in feet

Table I-3. Vegetation Hydrologic Maturity And Snow Water Equivalent Ratios

	Vegetation Hydrologic Maturity (step 7)	Snow-water Equivalent Ratio (R)
A	Hydrologically Mature	1
B	Intermediate Hydrologic Maturity	1.5
C	Minimum Hydrologic Maturity	2
D	Non-Forested	2

Wind speed

Local wind speed primarily depends on the vegetative cover, with mature forest canopies significantly reducing the wind speed at the interface between the snowpack and the air. Daily average windspeed (mph) with a 50% exceedance rate (% of days) for an average storm for western Oregon will be used. This corresponds to an estimated 15 mph.

Precipitation

Rate of precipitation is calculated, using the 2 year 24 hour precipitation, in. (step 1).

Step 11
Calculate water available for runoff.

Perform a zonal mean for each subwatershed:

$$M = \frac{A_1M_1+A_2M_2+\ldots A_nM_n}{A_1+A_2+\ldots A_n}$$

where:
M = snowmelt, in.
A = area, acres

Calculate water available for runoff for the existing condition by:

$$WAR = M + P$$

where:
WAR = water available for runoff, in./day
M = snowmelt, in./day
P = 2-year 24-hour precipitation, in.

Add the snowmelt (M) to the 2-year 24-hour precipitation (P) and track for each subwatershed in the 'Rain-on-Snow" derived data layer (step 4).

Step 12 –
Estimate peak flow for the existing condition. Estimate peak flows for each subwatershed (filtered set, step 4) by substituting the water available for runoff value (step 11) for the existing condition into the 2-year 24-hour streamflow regression equations (step 6) for the precipitation term. Compare the result with the 5-year 24-hour streamflow and indicate where it is exceeded.

Step 13 –
Estimate peak flow for the alternatives. Repeat steps 7 to 12 for the 10-year projection by re-classing the expected condition of vegetation (step 7). Merge the ecology stand establishment with attribute without legacy from the Options model derived data layer for the 10-year projection for each alternative with the "Existing Condition Hydrologic Maturity" for forest vegetation. Substitute cover class C for these areas.

Step 14 –
Conduct reference analysis. Replace the alternatives 10-year projections with the no harvest and maximum harvest on commercial forest lands reference analysis derived data layers. Order the analysis as in step 13.

Step 15 –
As a sensitivity analysis for the design storm, one standard error of the estimate will be applied to the USACE snowmelt equation for temperature and wind speed. For temperature, use 55 - (.0033 * E), where E = elevation in feet. For windspeed, use 25 mph. Modify scripts and rerun the analysis.

Analytical Conclusions

Rank those subwatersheds that exceed the 5-year 24-hour peakflow as sensitive for estimated peak flow increase.

Data Needs

- National Oceanic and Atmospheric Administration (NOAA) 2-year 24-hour Precipitation Frequency map of Oregon. Available in GIS raster format online: [http://www.nws.noaa.gov/ohd/hdsc/noaaatlas2.htm]
- USGS Flood Regions. Available in GIS raster format online: [http://water.usgs. gov/software/nff_manual/or/oregon_AFrame_3.gif]
- U.S. Weather Service Windspeed Frequency
- Classified 1996 imagery from the Interagency Vegetation Mapping Project TM (IVMP), including datalayers: Vegetation Canopy Cover, and Harvest History from 1996 to 2004
- GIS-derived data layer of hydroregions
- GIS-derived data layer of vegetation hydrologic maturity
- GIS-derived data layer of snow-water equivalent
- GIS-derived data layer of snowmelt
- Topography GIS coverage
- Watershed GIS coverage
- Waterbodies GIS coverage
- By alternative, GIS-derived data layer of 10-year projection stand establishment

Data Display

- Figure of hydroregions for the plan area
- Figure showing subwatersheds where the 2-year. 24-hour peak flow exceeds the 5-year, 24-hour peak flow for the existing condition, for each alternative's 10-year projection

Analytical Question #3

How does the pattern and intensity of new BLM road construction, under the alternatives, create disturbance and sources of fine sediment that may deliver to stream channels?

Analytical Assumptions

This analysis is based on use of a reference road. The analytical technique is an empirical approach patterned in part from the Washington State Department of Natural Resources Standard Methodology for Conducting Watershed Analysis, 1997 (v. 4.0), Appendix B.

The reference road will use the following assumptions: An in-sloped road with a ditch; moderate traffic (pickups sedans, and log haul <50% of the time); cut-slope gradient 1:1 (horizontal to vertical) and fill-slope gradient 1.5:1; initial ground cover density of zero on cut and fill slopes; sustained grade of 5-7 percent; and an average cross-drain spacing of 500 feet.

Proportions of the total long-term average road erosion rates attributed to the components of the standard road prism (Swift 1984, Burroughs and King 1989, Sullivan and Duncan 1980, Megahan unpub.) are:

- Road Tread 40%
- Cutslope and Ditch 40%
- Fillslope 20%

Roads differ in their inherent erodibility, or erosion potential, due to the geology, or parent material on which they are constructed as seen in *Table I-4* (*Basic erosion rates*). Sediment yields from older roads with undisturbed ditches are much smaller than sediment yields from newer roads or roads with disturbed ditches. Maintenance of ditchlines can increase sediment yields.

The basic erosion rate for road erodibility is decreased by vegetative cover and surface roughness on cut and fills slopes. *Table I-5 (Groundcover correction factor for cut and fill slopes*) shows reduction factors from the basic erosion rate.

The basic erosion rate for road erodibility is decreased by road tread surfacing. *Table I-6* (*Factors for road tread surfacing*) shows reduction factors based on types of surfacing.

The basic erosion rate for road erodibility is increased by road traffic and wet weather haul on natural surface and gravel roads. *Table I-7* (*Traffic and Precipitation Factors*) shows erodibility increase factors based on precipitation bands and traffic level.

Table I-4. Basic Erosion Rates In Tons/Acre Of Road Prism/Year

General Category	Geologic Parent Material	Road Age	
		New 0-2 Years	Old > 2 Years
High	Mica schist, Volcanic ash, Highly weathered sedimentary	110	60
High/Moderate	Quartzite, Course-grained granite	110	30
Moderate	Fine-grained granite Moderately weathered rock Sedimentary rocks	60	30
Low	Competent granite, Basalt, Metamorphic rocks, Relatively unweathered rocks	20	10

Sources: Kochendorfer, J. N. and J. D. Helvey 1984; Hayden et al. 1991; Megahan and Kidd 1972; Reid and Dunne 1984; Sullivan and Duncan, U.S. Forest Service unpublished data.

Table I-5. Groundcover Correction Factor For Cut And Fill Slopes

Ground Cover Density Factor	Factor
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

Sources: Megahan 1991, Burroughs and King 1989, Megahan unpublished data.

Table I-6. Factors For Road Tread Surfacing

Surfacing Material Factor	Factor
Paved	0.03
Gravel, greater than 6 inches deep	0.2
Native soil/rock	1.00

Table I-7. Traffic And Precipitation Factors

Traffic Use/Road Category	Annual Precipitation		
	<47 inches	47 inches – 118 inches	>118 inches
Heavy Traffic/Active Mainline	20	50	120
Moderate Traffic/Active Secondary	2	4	10
Light Traffic/Non Active	1	1	1

Sources: Reid and Dunne 1984; Sullivan and Duncan unpublished

Sediment Delivery

- Sediment delivery to streams is affected by the road drainage system design, including road prism shape, proximity of the road to the stream channel, and length of road draining directly into a stream at crossings.
- Sediment delivery to streams by road segment: Assume that a road segment does not deliver if the road does not cross a stream channel.
- Sediment delivery to streams by ditches: Assume 100% delivery of sediment to streams from the road prism and cutslope before application of factors.
- Sediment delivery to streams by diffuse sources: Assume 10% delivery of sediment to streams from the fill slope before application of factors.
- Best Management Practices can substantially reduce sediment delivery from roads.

Sediment Delivery Distance

- Roads near ridges have little direct effect on sediment delivery to streams.
- Generalized distances for sediment filtration effectiveness occur much sooner (25-100 feet) for diffuse sources of sediment delivery compared to concentrated sources (200 feet), such as road ditch lines draining into the riparian area (CH2MHill 1999).
- Wemple (1998 cited in Jones et al. 2000) found that road segments that have stream connection pathways such as roadside ditches have potential to deliver surface eroded sediment to streams. Road segments not connected to streams by ditch lines or gullies or having more than 25 to 100 feet of filtering forest floor duff and vegetation (depending on slope, soil properties, and surface roughness) between them and a stream are usually not at risk of delivering sediment to streams.
- Below culverts, sediment travel distance in streams decreases with increasing roughness, such as debris and obstructions (Brake et al. 1997).
- Concentrated and diffuse sources of sediment delivery in this analysis are assumed to be within 200 feet of stream channels.

Road Traffic

- Frequent heavy truck traffic can grind resistant road surfacing such as gravels into smaller particles that can wash into ditchlines during rainstorms. Material type, and traffic level and rate determine the quantity of sediment available for transport, and the rainfall determines the transport capacity (Reid and Dunne 1984).

Analytical Methodology and Technique

The technique relies on ARC GIS GRID processes for analyzing spatial data. Logical and mathematical operations were written as scripts, based on watershed analysis methodologies. The analysis is performed by fifth-field watersheds within the plan area.

Step 1 -
Build a basic erosion rate (BER) data layer from the BLM GIS Geology theme by matching the parent materials in the *Table I-4* (*Basic erosion rates*), to the theme mapped designations with input from Geologist and Soil Scientist.

Step 2 -
Build a derived data layer labeled "Streams" from the BLM GIS Watercourses data theme that includes all intermittent and perennial streams.

Step 3 -
Buffer the Streams derived data layer (Step 2) to 200 feet and make a new derived data layer labeled "Sediment Delivery Buffer".

Step 4 -
Intersect and clip BLM GIS GTRN (roads) data theme with the sediment delivery buffer derived data layer (step 3) for all lands. Label new derived data layer "Stream Proximity Roads".

Step 5 –
Refine the stream proximity roads derived data layer (step 4) and exclude road segments that do not cross stream channels. Road segment origin must be further than 30 feet from streams to be excluded.

Step 6 -
Build a table of specific vegetative correction factors by fifth-field watershed using Table I-5 (*Groundcover correction factor for cut and fill slopes*). Table I-12 (*Groundcover correction factors for cut and fill slopes by fifth-field watershed*) shows the groundcover correction factors used (included at the end of this question).

Step 7 -
Use selected Prism Climate Model outputs to build a derived data layer labeled "Average Annual Precipitation" by fifth-field watershed. From the Oregon Climate Service PRISM Products page, online: [http://www.ocs.orst.edu/prism/products/] select the 30-arcsec (800m) normal grids for precipitation for the period 1971-2000.

Step 8 -
Calculate the traffic factor from Table I-7 (*Traffic and precipitation factors*) by merging the precipitation dominated and rain-on-snow hydro region (from peakflow planning criteria) with the average annual precipitation data layer (step 7) and develop a new data layer labeled "Traffic factors." Classify into three precipitation bands: <47", 47-118" and >118" from Table I-7. Assign traffic factors for moderate traffic where <47" equal 2, 47-118" equal 4, and >118" equal 10.

Step 9 –
For each road segment, add attributes to the data tables for the stream proximity roads derived data layer selected set (step5). Calculate the road segment lengths by surface type within the BLM GIS GTRN roads data layer for BLM and other ownerships and add to the data tables. Assign BLM controlled roads in the planning area from BLM GIS GTRN (roads) theme to BLM.

Step 10 -
For each road segment within the stream proximity roads derived data layer selected set (steps 5 and 9) build a logical calculation sequence as scripts to determine potential sediment delivery from the cut slope, road tread and fill slope (calculations 1, 2 and 3). Refer to *Table I-8 (Factor Definition Table)* for factor explanation:

Table I-8. Factor Definition Table

Factor	Factor Definition
BER	Basic erosion rate in tons/acre/year
PCD	Proportion of cutslope and ditch erosion to the roaded cross section; 0.40
RT	Proportion of road tread erosion to the roaded cross section; 0.40
FS	Proportion of fill slope erosion to the roaded cross section; 0.20
GCD	Groundcover density factor (0.18-1.0)
RST	Road surface type factor; 0.03 paved, 0.2 gravel and 1.0 native surface
TF	Traffic factor within precipitation dominated area for annual precipitation: <47 inches equal 20, 47-118 inches equal 50 , >118 inches equal 120
Cut slope width	Cut slope width in feet; generalized 15 feet
Ditch width	Ditch width in feet; generalized 3 feet
Road tread width	Road tread width in feet; generalized 14 feet
Road prism width	Road prism width in feet; generalized 20 feet
Fill slope width	Fill slope width in feet; generalized 10 feet
Road length	Road length in feet, up gradient of stream crossings to the buffer limit
43560	Factor to convert square feet to acres

Existing Condition:

Return basic erosion rate (BER) value from the basic erosion rate derived data layer of > two year old road age (step 1).

Return road surface type factor (RST) (from *Table I-6*).
Return ground cover density (GCD) factor from *Table I-12* (step 6).
Return traffic factor (TF) (step 8).

Calculate:

1 [BER * PCD * GCD] * [((cutslope width) + (ditch width) + (road prism width - road tread width / 2)) * road length]/ 43560

2 *where RST = 0.03*
[BER * RT * road surface type factor * [road tread width * road length]/43560

else:
[BER * RT * RST] * [TF] * [road tread width * road length]/43560

3 [(BER * FS * GCD) * 0.10] * [((fillslope width) + (road prism width - road tread width / 2)) * road length]/43560

3 [(BER * 0.2 * GCD) * 0.10] * [((10) + (3) * road length]/43560

Sum 1, 2 and 3.
Next

Alternative 10-Year Projection:

Repeat existing condition calculation except for the following modifications in these steps:

***Step 1*-**
Return basic erosion rate (BER) value from the basic erosion rate derived data layer of < 2 year old road age, and *Table I-4* (*Basic erosion rates*).

Step 9-
Calculate the road segment lengths for permanent aggregate and natural surface roads constructed by 2016. No paved roads are planned.

Step 11 –
Because the alternative roads 10 year projections are generated from a 1/3 sample of sections where harvest is projected to occur, the following adjustments will be made.

Develop ratio R1:

$$R1 = \frac{\text{Length of road by surface type within the sediment delivery buffer in the watershed}}{\text{Length of road by surface type in the watershed}}$$

Populate the denominator of the ratio by using *Table I-9* (*Projected permanent roads by alterative by 2016*).

Develop ratio R2:

$$R2 = \frac{R1}{\text{Proportion of existing road by surface type within the sediment delivery buffer to all roads of that type}}$$

Populate the denominator of ratio R2, by using *Table I-10* (*Proportion of existing roads on BLM within the sediment delivery buffer to all roads by surface type*).

For the PRMP, no spatial roads sampling was completed due to extensive sampling in the other alternatives. However road lengths were determined in each watershed based on expected miles of new permanent natural and aggregate road needed for regeneration volume and thinning volume.

For the PRMP, the numerator of R1 is determined by multiplying the expected new permanent miles of road by 2016 in each watershed by a factor of 0.068593174 for natural surface roads and 0.071248241 for aggregate roads. The factors result in expected length of road within the sediment delivery buffer based on an average of Alternative 1 and Alternative 3.

For the PRMP, the potential sediment delivery in tons/year attributed to the numerator in R1 is calculated by using 102.95 tons/year for natural surface roads and 34.74 tons/year for aggregate roads. The sediment yields are an average of Alternative 1 and Alternative 3 sediment delivery buffer yields.

Table I-9. Projected Permanent Roads By Alternative By 2016

Alternative	Rocked Roads (miles)	Natural Roads (miles)
No Action	250.31	94.49
Alternative 1	384.98	128.44
Alternative 2	494.55	109.64
Alternative 3	393.66	131.95
Proposed RMP	449.06	249.96

Data is based on road construction 10 year scenario estimates for timber volume per foot of road for sum of regeneration harvests, thinning and partial cuts for all districts.

Table I-10. Proportion Of Existing Roads On BLM Within The Sediment Delivery Buffer To All Roads By Surface Type

Natural	Aggregate	Paved	Total
12.18	18.15	5.37	35.70

Step 12
Calculate data for the display table.

Existing Condition:

Sum miles of stream proximity roads (inside the sediment delivery buffer) by surface type; paved, aggregate and natural for BLM and other land ownerships for each watershed. Sum all watersheds.

Calculate potential sediment delivery in tons/year by surface type: paved, aggregate and natural for BLM and other land ownerships for each watershed. Sum the categories for all watersheds.

Calculate potential sediment delivery in tons mile^2/year for BLM and other land ownerships for each watershed. Sum potential sediment delivery for all watersheds for BLM and other land ownerships and divide by the total landbase.

Alternatives:

Determine the expected road length within the sediment delivery buffer for each watershed, by dividing the alternative 1/3 sample results by R2. Sum miles of expected stream proximity roads (inside the sediment delivery buffer) for each alternative by surface type; aggregate and natural on BLM for each watershed. Sum all watersheds.

Determine the potential sediment delivery in tons/year for each watershed, by dividing the alternative 1/3 sample results within the sediment delivery buffer by R2. Calculate potential sediment delivery for each alternative in tons/year by surface type: aggregate and natural for BLM for each watershed. Sum the categories for all watersheds.

Calculate potential sediment delivery in tons mile^2/year for BLM and other land ownerships for each watershed. Sum potential sediment delivery for all watersheds for BLM and other land ownerships and divide by the total landbase.

Analytical Conclusions

- Rank of alternatives by their effect on road sources of potential fine sediment delivery to stream channels.
- Comparison of fine sediment delivery to that which occurs under the existing condition.

Data Needs

- Proposed new road 10-year projection, by alternative.
- GIS-derived data layer of basic erosion rate.
- GIS-derived data layer of stream proximity roads derived data layer for the existing condition.
- GIS-derived data layer of stream proximity 10-year projection roads for each alternative.
- Prism model of average annual precipitation for the precipitation hydroregion.

Data Display

Populate table I-11 (Potential Sediment Delivery, By Alternative From Roads)

Table I-11. Potential Sediment Delivery, By Alternative From Roads

Current Condition and Condition under the Alternatives by 2016	Roads Within Fine Sediment Delivery Distance (miles)		Potential Fine Sediment Delivery (tons/year[3])		Watershed Average Potential Fine Sediment Delivery (tons/sq. mile/year [3])	
Current Condition						
Existing Roads[1]	**BLM**	**Other**	**BLM**	**Other**	**BLM**	**Other**
Natural						
Aggregate						
Paved						
Totals						
No Action Alternative						
New Roads (by 2016)[4]						
Natural						
Aggregate						
Paved						
Totals						
Proposed RMP						
New Roads (by 2016)[4]						
Natural						
Aggregate						
Paved						
Totals						
Alternative 1						
New Roads (by 2016)[4]						
Natural						
Aggregate						
Paved						
Totals						
Alternative 2						
New Roads (by 2016) [4]						
Natural						
Aggregate						
Paved						
Totals						
Alternative 3						
New Roads(by 2016) [4]						
Natural						
Aggregate						
Paved						
Totals						

[1] Includes BLM and BLM-controlled roads and the private roads within the planning area from BLM GIS GTRN (roads) coverage.
[2]Delivery distances include the road segments within 200 feet of stream channels, where ditchflow carrying fine sediment could enter streams.
[3]The calculations for these planning criteria estimates were calculated by surface type for each fifth-field watershed and summed for the planning area.
[4]New roads include BLM new roads only. Information is not available to predict the number of miles of new roads on other lands.

Table I-12. Groundcover Correction Factors For Cut And Fill Slopes By Fifth Field Watershed

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Abernethy Creek	1709000704	0.37
Abiqua Creek-Pudding River	1709000901	0.37
Althouse Creek	1710031102	0.37
Applegate River-McKee Bridge	1710030902	0.37
Bear Creek	1710030801	0.53
Beaver Creek	1801020609	0.37
Beaver Creek-Columbia River	1708000302	0.18
Beaver Creek-Waldport Bay	1710020505	0.18
Big Butte Creek	1710030704	0.28
Big Creek	1708000602	0.18
Big Creek-Vingie Creek	1710020508	0.18
Big Elk Creek	1710020402	0.18
Blue River	1709000404	0.37
Boulder Creek	1710030106	0.18
Briggs Creek	1710031107	0.37
Buck Creek	1712000501	0.53
Bull Run River	1708000105	0.18
Butte Creek-Pudding River	1709000902	0.37
Calapooia River	1709000303	0.37
Calapooya Creek	1710030302	0.37
Canton Creek	1710030109	0.37
Cape Ferrelo Frontal	1710031206	0.37
Chetco River	1710031201	0.37
China Peak	1801020901	0.37
Clatskanie River	1708000303	0.18
Clearwater River-North Umpqua River	1710030104	0.18
Collawash River	1709001101	0.37
Columbia Gorge Tributary	1708000107	0.18
Columbia River-Baker Bay	1708000605	0.18
Columbia River-Cathlamet Channel	1708000307	0.18
Columbia River-Hayden Island	1709001205	0.18
Columbia Slough-Willamette River	1709001203	0.18
Coos Bay Frontal	1710030403	0.18
Copic Bay	1801020411	0.63
Cottonwood Creek	1801020607	0.37
Crabtree Creek	1709000606	0.53
Dairy Creek	1709001001	0.18
Deadwood Creek	1710020605	0.18
Deer Creek	1710031105	0.37
Detroit Reservoir-Blow Out Divide Creek	1709000503	0.37
Devils Lake-Moolack Frontal	1710020409	0.18
Diamond Lake	1710030101	0.28
Drews Creek	1802000101	0.63

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Drift Creek	1710020503	0.18
Eagle Creek	1709001105	0.18
East Fork Coquille River	1710030503	0.18
East Fork Illinois River	1710031101	0.37
Elk Creek	1710030303	0.28
Elk Creek-Rogue River	1710030705	0.58
Elk Creek-South Umpqua	1710030204	0.37
Elk River	1710030603	0.37
Evans Creek	1710030803	0.58
Fall Creek	1709000109	0.37
Fish Creek	1710030105	0.18
Fishhole Creek	1801020206	0.58
Five Rivers-Lobster Creek	1710020502	0.18
Fourmile Creek	1801020303	0.28
Gales Creek	1709001002	0.18
Gerber Reservoir	1801020405	0.53
Grave Creek	1710031003	0.53
Hills Creek	1709000102	0.28
Hills Creek Reservoir	1709000105	0.28
Horse Creek	1709000402	0.37
Humbug Mountain-Nesika Beach Frontal	1710030604	0.37
Hunter Creek	1710031205	0.37
Illinois River-Josephine Creek	1710031106	0.37
Illinois River-Klondike Creek	1710031108	0.37
Illinois River-Lawson Creek	1710031111	0.37
Indian Creek	1801020902	0.37
Indian Creek-Lake Creek	1710020606	0.18
Indigo Creek	1710031110	0.37
ISLAND IN OCEAN	1000000000	0.77
Jackson Creek	1710030202	0.37
Jenny Creek	1801020604	0.37
Johnson Creek	1709001201	0.37
Jumpoff Joe Creek	1710031002	0.45
Kilchis River	1710020306	0.18
Klamath Lake	1801020302	0.45
Klamath Marsh-Crater Lake	1801020104	0.45
Klamath Marsh-Jack Creek	1801020102	0.37
Klamath River-Copco Reservoir	1801020603	0.63
Klamath River-Iron Gate Reservoir	1801020605	0.63
Klamath River-John C Boyle Reservoir	1801020602	0.63
Lake Creek	1710020604	0.18
Lake Ewauna-Upper Klamath River	1801020412	0.53
Lakeside Frontal	1710030404	0.18
Langell Valley	1801020406	0.53
Lemolo Lake	1710030102	0.28

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Little Applegate River	1710030903	0.28
Little Butte Creek	1710030708	0.45
Little Fall Creek	1709000108	0.37
Little Nestucca River	1710020301	0.18
Little North Santiam River	1709000505	0.18
Little River	1710030111	0.37
Lobster Creek	1710031007	0.37
Long Tom River	1709000301	0.28
Lower Alsea River	1710020504	0.18
Lower Applegate River	1710030906	0.45
Lower Clackamas River	1709001106	0.18
Lower Coast Fork Willamette River	1709000204	0.37
Lower Coquille River	1710030505	0.18
Lower Cow Creek	1710030209	0.37
Lower Klamath Lake	1801020414	0.53
Lower Lost River	1801020409	0.53
Lower McKenzie River	1709000407	0.37
Lower Middle Fork of Willamette River	1709000110	0.37
Lower Molalla River	1709000906	0.37
Lower Nehalem River	1710020203	0.18
Lower Nehalem River-Cook Creek	1710020206	0.18
Lower North Santiam River	1709000506	0.18
Lower North Umpqua River	1710030112	0.18
Lower Rogue River	1710031008	0.28
Lower Sandy River	1708000108	0.18
Lower Siletz River	1710020407	0.18
Lower Siuslaw River	1710020608	0.18
Lower Smith River	1801010104	0.37
Lower Smith River-Lower Umpqua River	1710030307	0.18
Lower South Umpqua River	1710030213	0.37
Lower South Yamhill River	1709000804	0.37
Lower Tualatin River	1709001005	0.18
Lower Umpqua River	1710030308	0.18
Lower Yaquina River	1710020403	0.18
Luckiamute River	1709000306	0.37
Marys River	1709000305	0.28
McKenzie River-Quartz Creek	1709000405	0.37
Meiss Lake	1801020503	0.63
Mercer Lake Frontal	1710020507	0.18
Miami River	1710020307	0.18
Middle Applegate River	1710030904	0.37
Middle Clackamas River	1709001104	0.18
Middle Columbia River-Eagle Creek	1707010513	0.18
Middle Cow Creek	1710030207	0.45

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Middle Fork Coquille River	1710030501	0.28
Middle Fork Smith River	1801010102	0.37
Middle Fork Willamette River-Lookout Point Reservoir	1709000107	0.37
Middle Nehalem River	1710020202	0.18
Middle North Santiam River	1709000504	0.18
Middle North Umpqua River	1710030107	0.18
Middle Sandy River	1708000104	0.18
Middle Santiam River	1709000601	0.18
Middle Siletz River	1710020405	0.18
Middle South Umpqua River	1710030210	0.37
Middle South Umpqua River-Dumont Creek	1710030203	0.37
Mill Creek-Lower Umpqua River	1710030305	0.18
Mill Creek-South Yamhill River	1709000803	0.37
Mill Creek-Willamette River	1709000701	0.37
Millicoma River	1710030402	0.18
Mohawk River	1709000406	0.28
Mosby Creek	1709000202	0.28
Muddy Creek	1709000302	0.28
Myrtle Creek	1710030211	0.37
Necanicum River	1710020101	0.18
Nestucca River	1710020302	0.18
New River Frontal	1710030601	0.18
North Fork Breitenbush River	1709000502	0.18
North Fork Coquille River	1710030504	0.18
North Fork of Middle Fork Willamette River	1709000106	0.37
North Fork of Nehalem River	1710020205	0.18
North Fork Siuslaw River	1710020607	0.18
North Fork Smith River	1801010101	0.37
North Fork Sprague River	1801020204	0.53
North Fork Willow Creek	1801020402	0.63
North Yamhill River	1709000806	0.53
Northwest of Klamath Lake	1801020103	0.37
Oak Creek	1709000304	0.37
Oak Grove Fork Clackamas River	1709001103	0.37
Olalla Creek-Lookingglass Creek	1710030212	0.37
Pistol River	1710031204	0.37
Plympton Creek	1708000306	0.18
Poe Valley-Yonna Valley	1801020407	0.53
Quartzville Creek	1709000602	0.63
Rickreall Creek	1709000702	0.53
Rock Creek-North Umpqua River	1710030110	0.37
Rock Creek-Pudding River	1709000903	0.37

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Rock Creek-Siletz River	1710020406	0.37
Rock Creek-Tualatin River	1709001004	0.18
Rogue River-Gold Hill	1710030802	0.45
Rogue River-Grants Pass	1710030804	0.45
Rogue River-Hellgate Canyon	1710031001	0.45
Rogue River-Horseshoe Bend	1710031004	0.45
Rogue River-Lost Creek	1710030703	0.37
Rogue River-Shady Cove	1710030707	0.58
Rogue River-Shasta Costa Creek	1710031006	0.37
Rogue River-Stair Creek	1710031005	0.37
Row River	1709000201	0.28
Salmon Creek	1709000104	0.37
Salmon River	1708000101	0.28
Salmon River-Siletz River	1710020408	0.18
Salmonberry River	1710020204	0.18
Salt Creek-South Yamhill River	1709000805	0.37
Salt Creek-Willamette River	1709000103	0.28
Scappoose Creek	1709001202	0.18
Scoggins Creek	1709001003	0.18
Senecal Creek-Mill Creek	1709000904	0.37
Siltcoos River-Tahkenitch Creek Frontal	1710020701	0.18
Silver Creek	1710031109	0.63
Sixes River	1710030602	0.37
South Fork Coos River	1710030401	0.18
South Fork Coquille River	1710030502	0.18
South Fork McKenzie River	1709000403	0.37
South Fork Rogue River	1710030702	0.28
South Fork Sprague River	1801020205	0.53
South Santiam River	1709000603	0.37
South Santiam River-Foster Reservoir	1709000604	0.37
South Santiam River-Hamilton Creek	1709000608	0.37
South Umpqua River	1710030205	0.37
Spencer Creek	1801020601	0.45
Sprague River above Williamson	1801020207	0.58
Sprague River Valley	1801020208	0.53
Spring Creek-Sand Lake-Neskowin Creek Frontal	1710020309	0.18
Steamboat Creek	1710030108	0.28
Sucker Creek	1710031103	0.18
Swan Lake Valley	1801020408	0.53
Sycan River above Sprague River	1801020203	0.53
Sycan River above Sycan Marsh	1801020201	0.53
Sycan River at Sycan Marsh	1801020202	0.53
Thomas Creek	1709000607	0.53
Tillamook Bay	1710020308	0.18

Watershed Name	Hydrologic Unit Code	Vegetation Correction Factor
Tillamook River	1710020303	0.18
Trail Creek	1710030706	0.58
Trask River	1710020304	0.18
Umpqua River-Sawyers Rapids	1710030304	0.18
Upper Alsea River	1710020501	0.18
Upper Applegate River	1710030901	0.37
Upper Clackamas River	1709001102	0.18
Upper Coast Fork Willamette River	1709000203	0.28
Upper Cow Creek	1710030206	0.58
Upper Lost River	1801020404	0.63
Upper McKenzie River	1709000401	0.37
Upper Middle Fork Willamette River	1709000101	0.18
Upper Molalla River	1709000905	0.63
Upper Nehalem River	1710020201	0.18
Upper North Santiam River	1709000501	0.37
Upper North Umpqua River	1710030103	0.18
Upper Rogue River	1710030701	0.28
Upper Sandy River	1708000103	0.37
Upper Siletz River	1710020404	0.53
Upper Siuslaw River	1710020601	0.18
Upper Smith River	1710030306	0.18
Upper South Umpqua River	1710030201	0.37
Upper South Yamhill River	1709000801	0.37
Upper Umpqua River	1710030301	0.18
Upper Yaquina River	1710020401	0.18
West Fork Cow Creek	1710030208	0.37
West Fork Illinois River	1710031104	0.37
Wildcat Creek	1710020603	0.18
Wiley Creek	1709000605	0.37
Willamette River-Chehalem Creek	1709000703	0.37
Willamina Creek	1709000802	0.37
Williams Creek	1710030905	0.45
Williamson River-Jackson Creek	1801020101	0.63
Williamson River below Klamath Marsh	1801020105	0.53
Wilson River	1710020305	0.18
Winchuck River	1710031207	0.37
Wolf Creek	1710020602	0.18
Wood River	1801020301	0.37
Yachats River	1710020506	0.18
Yamhill River	1709000807	0.37
Youngs River	1708000601	0.18
Zigzag River	1708000102	0.18

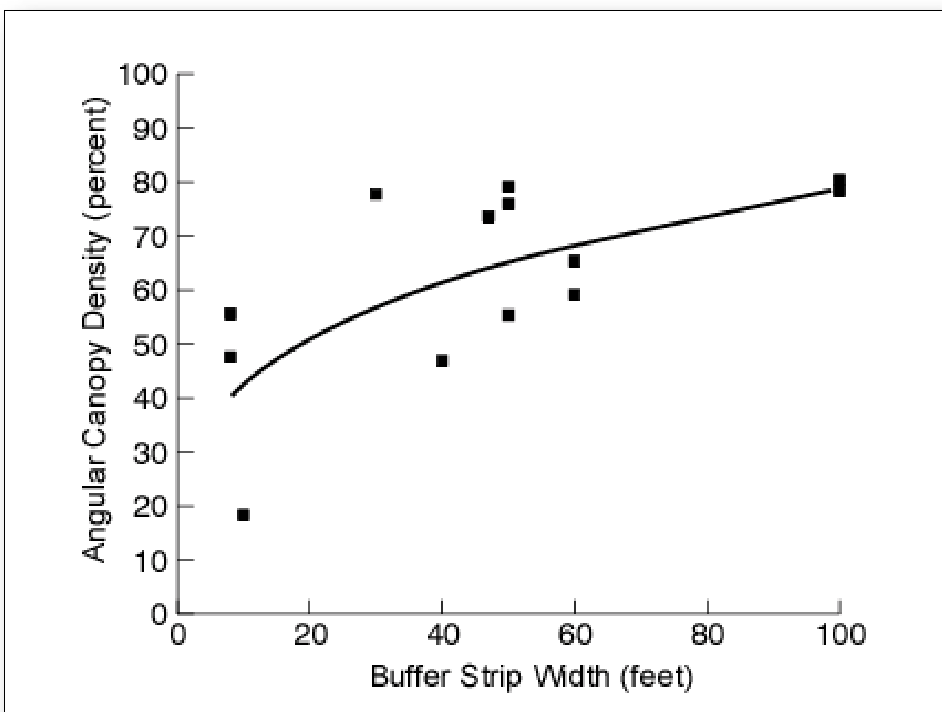
Analytical Question # 4

To what extent will each alternative maintain effective shade along streams, lakes and wetlands?

Analytical Assumptions

- Maintaining streamside shade is a surrogate for meeting the Department of Environmental Quality (DEQ) temperature standard. Northwest Forest Plan Temperature Total Maximum Daily Load (TMDL) Implementation Strategies (2005) demonstrate how retention and variable retention areas meet shade goals and the DEQ temperature standard. These are described as primary and secondary shade zones. The derivation of these zones is based on factors including seasonality of streams, topography, forest vegetation, and solar physics.
- Perennial streams are considered in this analysis, because of the influence that forest shade has on maintaining cool water temperatures during the summer.
- Mountainous topography can block solar radiation through parts of the day along many stream segments.
- Forest trees near stream channels and dense stands can block solar radiation and cast shadows across the stream. Angular canopy density (ACD) is the measure of canopy closure as projected in a straight line from the stream surface to the sun, as it varies through the day. The ACD value for a given buffer depends on the spacing of forest crowns. As vegetation becomes more open through wider spacing, more width of vegetation is needed to achieve the same ACD for the similar vegetation with closer spacing. Higher ACD is achieved with lower sun angles and higher canopy density. Figure I-3, *Angular Canopy Density (ACD) And Buffer Widths For Small Streams In Western Oregon* (Brazier and Brown 1972) illustrates that a buffer strip width of 60 feet will result in an angular canopy density of 65 percent.

Figure I-3. Angular Canopy Density (ACD) And Buffer Widths For Small Streams In Western Oregon



Effective shade is the total amount of radiant energy prevented from reaching a stream in a solar day. Because sun path and azimuth changes throughout the day forest vegetation has different efficiencies in blocking radiation for different time periods. As seen in Figure I-6 (*Solar Pathfinder*) for 43° to 49° N latitude (Boyd 1999), most solar heating occurs between 10:00 a.m. and 2:00 p.m. Park (1993) has shown that the width of primary riparian streamside areas will vary as a function of tree height and terrain slope as viewed in *Table I-13* (*Primary shade zone distance of riparian trees*).

The planning criteria assume the secondary shade zone is defined as the outer edge of the primary shade zone to 100 feet. There is marginal improvement of ACD past 100 feet as shown in *Figure I*-3. Significant temperature rises do not occur when effective shade is ≥ 80% (*Figures I-4 and I-5*).

Figure I-4. Angular Canopy Density (ACD) And Stream Shade (Park 1991)

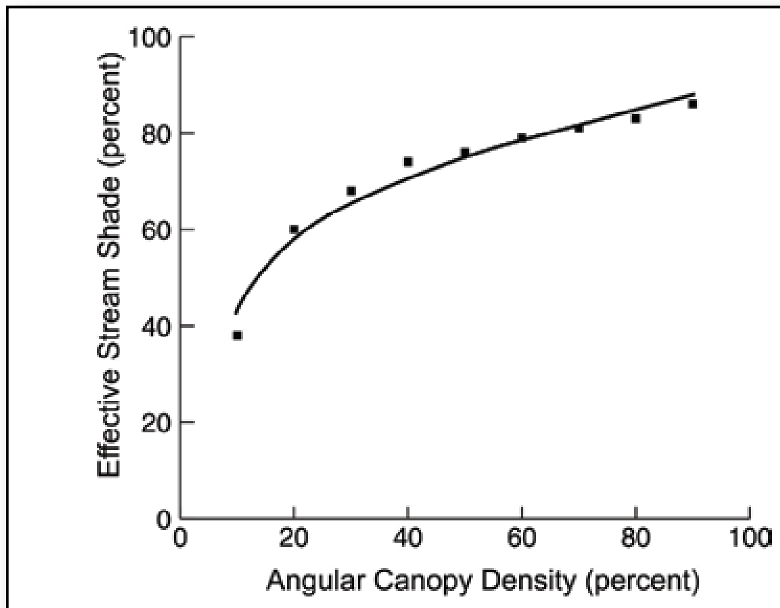
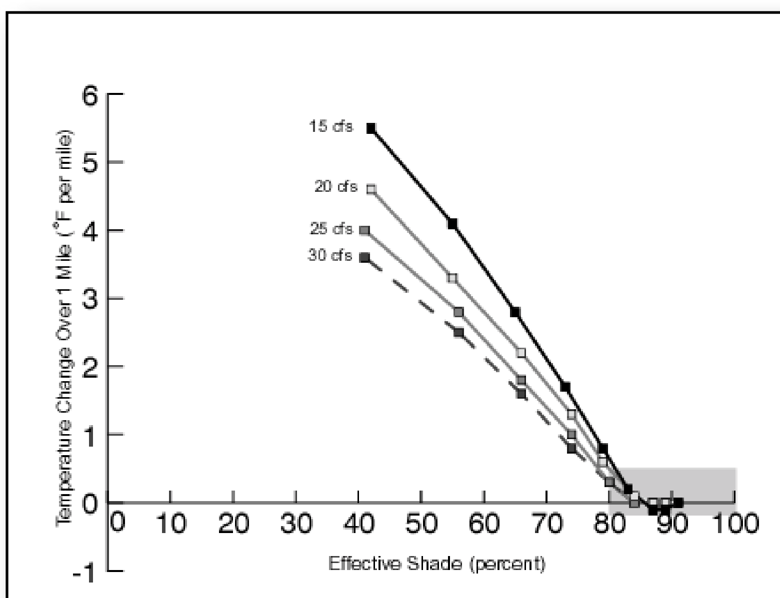


Figure I-5. Effective Stream Shade And Change In Stream Temperature



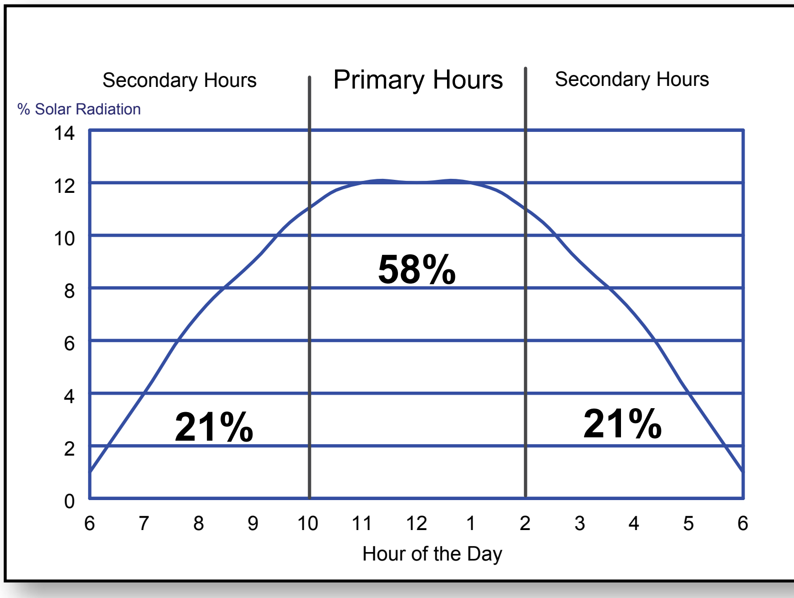


Figure I-6.
Solar Pathfinder

Table I-13. Primary Shade Zone Distance Of Riparian Trees (In Feet)

Height of tree	Hill slope <30%	Hill slope 30 to 60%	Hill Slope >60%
Trees < 20 feet	12	14	15 feet
Trees 20 to 60 feet	28	33	55 feet
Trees >60 to 100 feet	50	55	60 feet
Source: Northwest Forest Plan Temperature TMDL Implementation Strategies, 2005.			

Forest treatments are assumed to fully meet effective shade and water quality standards within primary and secondary shade zones along streams, lakes, and wetlands when the following criteria are met:

- *Table I-13* (*Primary shade zone distance of riparian trees*) will be used to determine the width of the primary shade zone. Vegetation thinning in the primary shade zone will not result in less than 80% effective shade.
- Vegetation thinning in the secondary shade zone will not result in less than 50% canopy closure post harvest.

For modeling purposes, 60 feet width will be used to define the boundary of the primary shade zone for all combinations of topography and vegetation, and 100 feet will be used to define the boundary of the secondary shade zone.

Analytical Methodology and Technique

Step 1 -
Reclassify the watercourses GIS theme to derive a perennial stream data layer.

Step 2 -
Buffer the perennial streams, lakes, and wetlands to 60 feet. Label this derived data layer Primary Shade Zone".

Step 3 -
Buffer the perennial streams, lakes, and wetlands to 100 feet.

Step 4 -
Intersect the Primary Shade Zone derived data layer (step 2) with the derived data layer derived (step 3). Label the difference between the Primary Shade Zone and the boundary f 100 feet "Secondary Shade Zone".

Step 5 -
Intersect the Primary Shade Zone with each alternative's primary riparian retention area. Calculate the miles of perennial stream not meeting the primary shade zone.

Step 6 -
Intersect the Secondary Shade Zone with each alternative riparian variable management riparian area that meets 50% canopy closure post harvest. Calculate the miles of perennial stream not meeting the secondary shade zone.

Analytical Conclusion

Rank alternatives by the extent that each alternative riparian area meets the primary and secondary shade zones on BLM-managed lands.

Data Needs

- GIS watercourses data theme
- GIS-derived data layer or detailed description of each alternative's full riparian retention and variable retention areas.

Data Display

Table I-14. Comparison Of Alternatives Not Meeting Effective Shade For Perennial Streams

Alternative	Perennial Streams Not Meeting Primary Shade Zones (Miles)	% of Total Perennial Stream	Perennial Stream Not Meeting Secondary Shade Zones (Miles)	% of Total Perennial Stream
No Action				
Alternative 1				
Alternative 2				
Alternative 3				

Analytical Question #5

How does the relative landslide density that would deliver to stream channels vary under the alternatives and between time periods within the harvest land base and all BLM-administered lands?

Analytical Assumptions

Process uses concepts described in "Effects of forest cover, topography, and sampling extent on the measured density of shallow, translational landslides" (Miller and Burnett 2007).

Shallow translational landslides depend upon fragile topographic locations, forest cover and water availability in the soils surface and subsurface layers. Extreme storms are highly correlated with increased rates of landsliding on susceptible sites. Since it is not known when the few large storms occur, a relative landslide density is determined. This is based on the observed locations of shallow landslides from extreme storms. The 1996 storms in western Oregon were extreme, with recurrence intervals of generally 50->100 years depending on location. Observed landslides from these storms were used in the topographic weighting and land cover classes' calibration datasets.

Analytical Methodology and Technique

The analysis is part of the Large Wood Delivery Model, used to analyze the differences in wood recruitment between the alternatives. The analysis uses Geospatial Information System (GIS) data layers as developed by the BLM for the plan revision. Computer program scripts will be run in a batch analysis that compile and arrange information from the spatial data layers, calibration datasets, and perform mathematical and logic operations, as developed by Miller and Burnett (2007, 2008) to analyze the differences in relative landslide density.

Step 1-
The analysis will include all BLM-administered lands using fifth-field scale Hydrologic Unit code watersheds.

Step 2-
Prepare and run analysis as part of the Large Wood Delivery Model.

A topographic weighting term using ground slope and the degree of convergence will be used, which varies spatially to reflect local topographic influences on landslide locations. Topographic weighting functions are calibrated to landslide inventories for the Coast, Cascades, and Klamath Provinces.

Landslide density, from the effect of vegetative cover, will be calculated using the calibration dataset in *Table I-15* (*1996 Siuslaw National Forest extreme storms*).

Table I-15. 1996 Siuslaw National Forest Extreme Storms

Forest Age Class, years	Landslide Density, number/mi^2
0-9	21.76
10 -100	8.03
>100	6.47

Roadmask files, 164 feet in width, will be created to indicate proximity to roads. The landslide density for any digital elevation model (DEM) cell within the road mask is multiplied by a factor of 2.2 (Miller and Burnett 2007).

Step 3-
Report the results for all alternatives and the No Harvest Reference Analysis for the 2006, 2016, 2026, 2056, and 2106 time periods, using the following:

- Report relative landslide density for those susceptible areas that could deliver to stream channels, based on the model calibration described in Miller and Burnett, 2008. All stream reaches will be included up to 20% gradient.
- Report results by the Oregon Coast Province, Cascades Province and Klamath Province. Include the Willamette Province and Klamath Falls Resource Area portion of the Basin and Range Province as the Cascades Province for reporting.
- Within provinces, categorize and report on the BLM land base as harvest land base, non-forest, riparian management area and late successional management area.
- Report as relative landslide density the numbers of landslides per square mile for each land area.
- Report the relative landslide densities as weighted averages.

Analytical Conclusions

By province compare the results for each alternative and each time period in the harvest land base. By province, compare the results for each alternative and each time period for all BLM-administered lands and the No Harvest Reference Analysis.

Data Needs

- GIS topography DEM's for the Plan Area
- GIS BLM roads data layer for the Plan Area
- GIS BLM forest inventory vegetation data layer
- BLM Options model structural stages by alternative and time period

Data Display

Show two comparison figures for the Oregon Coast, Cascades and Klamath Provinces, displaying how the relative landslide density varies over time under the alternatives. *Figure I-7* (*Relative landslide density under the alternatives in the harvest land base that would deliver to stream channels*) will show the harvest land base and *Figure I-8* (*Relative landslide density under the alternatives for all BLM-administered lands that would deliver to stream channels*) will show all BLM-administered lands (including non-forest, late successional management area, riparian management area and harvest land base). For each figure, the units of time will be shown along the x-axis, and relative landslide density as numbers per square mile will be shown along the y-axis.

Figure I-7. Relative Landslide Density Under The Alternatives In The Harvest Land Base That Would Deliver To Stream Channels

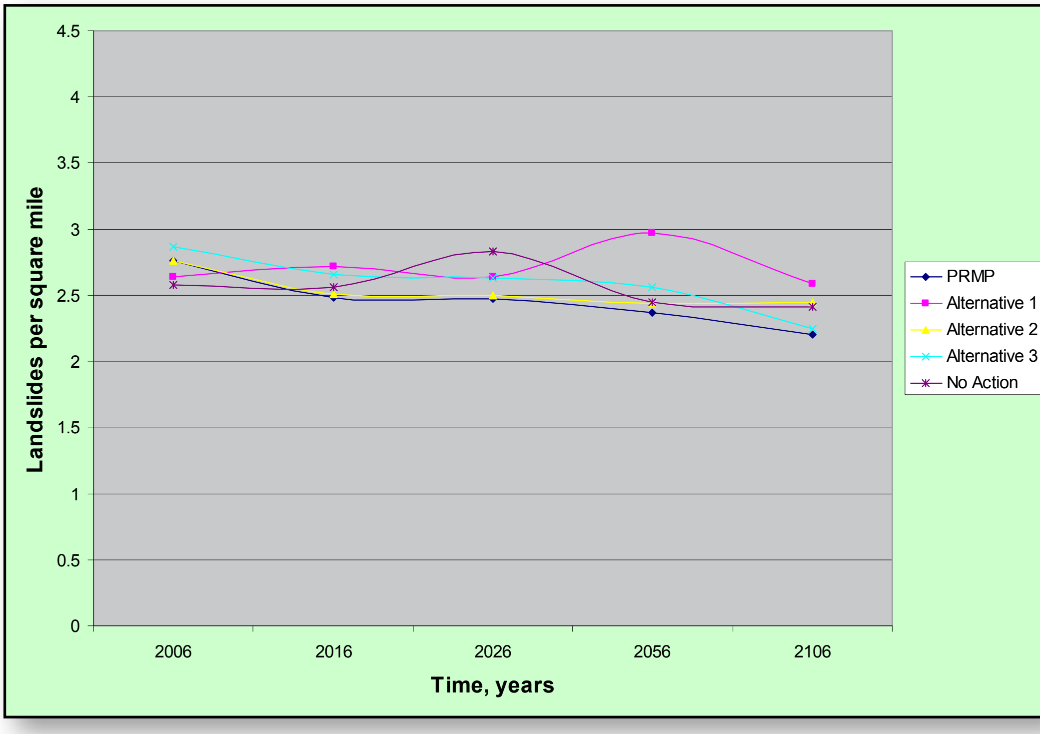
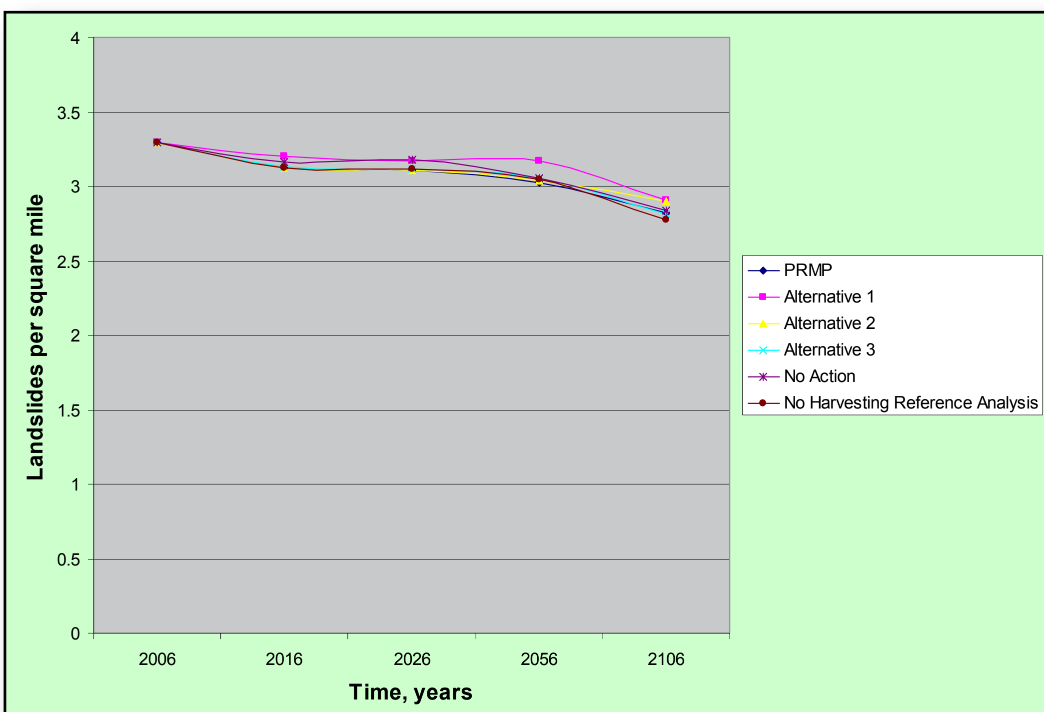


Figure I-8. Relative Landslide Density Under The Alternatives For All BLM-Administered Lands That Would Deliver To Stream Channels



Source Water Watersheds for Public Water Systems

The following table contains a list of source water watersheds for public water systems in the planning area. In many cases, the BLM administers a small portion of the watersheds.

Table I-16. Source water watersheds with BLM-administered lands in the planning area

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100003	ADAIR VILLAGE WATER SYSTEM	WILLAMETTE RIVER		8144	
4100003	ADAIR VILLAGE WATER SYSTEM	WILLAMETTE RIVER			226461
4100003	**ADAIR VILLAGE WATER SYSTEM**	**SUBTOTAL**	**650**	**8144**	**226461**
4100152	CITY OF BROWNSVILLE	CALAPOOIA RIVER		5254	
4100152	CITY OF BROWNSVILLE	CALAPOOIA RIVER			94920
4100152	**CITY OF BROWNSVILLE**	**SUBTOTAL**	**1500**	**5254**	**94920**
4100157	CANBY UTILITY BOARD	MOLALLA RIVER		2892	
4100157	CANBY UTILITY BOARD	MOLALLA RIVER			84687
4100157	**CANBY UTILITY BOARD**	**SUBTOTAL**	**12000**	**2892**	**84687**
4100169	CITY OF CANYONVILLE	CANYON CREEK		13247	
4100169	CITY OF CANYONVILLE	CANYON CREEK			9408
4100169	**CITY OF CANYONVILLE**	**SUBTOTAL**	**1265**	**13247**	**9408**
4100171	CITY OF CARLTON	PANTHER CREEK		1070	
4100171	CITY OF CARLTON	PANTHER CREEK			1003
4100171	**CITY OF CARLTON**	**SUBTOTAL**	**1570**	**1070**	**1003**
4100187	CLACKAMAS RIVER WATER-CLACKAMAS	CLACKAMAS RIVER		8399	
4100187	CLACKAMAS RIVER WATER-CLACKAMAS	CLACKAMAS RIVER			159669
4100187	**CLACKAMAS RIVER WATER-CLACKAMAS**	**SUBTOTAL**	**90000**	**8399**	**159669**
4100199	BEAVER WATER DISTRICT	BEAVER CREEK		1649	
4100199	BEAVER WATER DISTRICT	BEAVER CREEK			17000
4100199	**BEAVER WATER DISTRICT**	**SUBTOTAL**	**500**	**1649**	**17000**
4100202	COLTON WATER DISTRICT	JACKSON CREEK		598	
4100202	COLTON WATER DISTRICT	JACKSON CREEK			1536
4100202	**COLTON WATER DISTRICT**	**SUBTOTAL**	**1200**	**598**	**1536**

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100213	CITY OF COQUILLE	COQUILLE RIVER		67076	
4100213	CITY OF COQUILLE	RINK CREEK		0	
4100213	CITY OF COQUILLE	COQUILLE RIVER			248930
4100213	CITY OF COQUILLE	RINK CREEK			429
4100213	**CITY OF COQUILLE**	**SUBTOTAL**	**4300**	**67076**	**249359**
4100225	CITY OF CORVALLIS	SOUTH FORK ROCK CREEK		52	
4100225	CITY OF CORVALLIS	GRIFFITH CREEK			1051
4100225	CITY OF CORVALLIS	NORTH FORK ROCK CREEK			2155
4100225	CITY OF CORVALLIS	SOUTH FORK ROCK CREEK			3177
4100225	CITY OF CORVALLIS	WILLAMETTE RIVER			40593
4100225	**CITY OF CORVALLIS**	**SUBTOTAL**	**50101**	**52**	**46975**
4100236	CITY OF COTTAGE GROVE	LAYING CREEK		80	
4100236	CITY OF COTTAGE GROVE	ROW RIVER		37205	
4100236	CITY OF COTTAGE GROVE	LAYING CREEK			36989
4100236	CITY OF COTTAGE GROVE	PRATHER CREEK			3482
4100236	CITY OF COTTAGE GROVE	ROW RIVER			160279
4100236	**CITY OF COTTAGE GROVE**	**SUBTOTAL**	**8500**	**37285**	**200750**
4100239	LONDON WATER CO-OP	BEAVER CREEK		253	
4100239	LONDON WATER CO-OP	BEAVER CREEK			615
4100239	**LONDON WATER CO-OP**	**SUBTOTAL**	**50**	**253**	**615**
4100246	CITY OF CRESWELL	COAST FORK WILLAMETTE RIVER		26141	
4100246	CITY OF CRESWELL	COAST FORK WILLAMETTE RIVER			96969
4100246	**CITY OF CRESWELL**	**SUBTOTAL**	**3380**	**26141**	**96969**
4100248	CITY OF DALLAS	RICKREAL CREEK		2874	
4100248	CITY OF DALLAS	RICKREAL CREEK			15092
4100248	**CITY OF DALLAS**	**SUBTOTAL**	**12900**	**2874**	**15092**
4100250	MILO ACADEMY	LICKEY CREEK		227	
4100250	MILO ACADEMY	SOUTH UMPQUA RIVER		10090	
4100250	MILO ACADEMY	LICKEY CREEK			251
4100250	MILO ACADEMY	SOUTH UMPQUA RIVER			11365
4100250	**MILO ACADEMY**	**SUBTOTAL**	**195**	**10317**	**11616**
4100254	CITY OF DEPOE BAY	NORTH DEPOE BAY CREEK		7	

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100254	CITY OF DEPOE BAY	SOUTH DEPOE BAY CREEK		29	
4100254	CITY OF DEPOE BAY	NORTH DEPOE BAY CREEK			521
4100254	CITY OF DEPOE BAY	ROCKY CREEK			3396
4100254	CITY OF DEPOE BAY	SOUTH DEPOE BAY CREEK			2736
4100254	**CITY OF DEPOE BAY**	**SUBTOTAL**	**1060**	**36**	**6653**
4100260	CITY OF DRAIN	ALAN CREEK		235	
4100260	CITY OF DRAIN	BEAR CREEK		1133	
4100260	CITY OF DRAIN	ALAN CREEK			415
4100260	CITY OF DRAIN	BEAR CREEK			2235
4100260	**CITY OF DRAIN**	**SUBTOTAL**	**1145**	**1368**	**2650**
4100276	CITY OF ELKTON	UMPQUA RIVER		64481	
4100276	CITY OF ELKTON	UMPQUA RIVER			251660
4100276	**CITY OF ELKTON**	**SUBTOTAL**	**170**	**64481**	**251660**
4100279	CITY OF ESTACADA	CLACKAMAS RIVER (ESTACADA)		5714	
4100279	CITY OF ESTACADA	CLACKAMAS RIVER (ESTACADA)			341992
4100279	**CITY OF ESTACADA**	**SUBTOTAL**	**1910**	**5714**	**341992**
4100287	EUGENE WATER & ELECTRIC BOARD	MCKENZIE RIVER		25805	
4100287	EUGENE WATER & ELECTRIC BOARD	MCKENZIE RIVER			708818
4100287	**EUGENE WATER & ELECTRIC BOARD**	**SUBTOTAL**	**150,000**	**25805**	**708818**
4100297	FALLS CITY WATER DEPARTMENT	GLAZE CREEK		360	
4100297	FALLS CITY WATER DEPARTMENT	TEAL CREEK		186	
4100297	FALLS CITY WATER DEPARTMENT	GLAZE CREEK			288
4100297	FALLS CITY WATER DEPARTMENT	TEAL CREEK			2386
4100297	**FALLS CITY WATER DEPARTMENT**	**SUBTOTAL**	**1045**	**546**	**2674**
4100301	HECETA WATER DISTRICT	CLEAR LAKE			615
4100301	**HECETA WATER DISTRICT**	**SUBTOTAL**	**4500**		**615**
4100302	SILTCOOS HEIGHTS	SILTCOOS LAKE		825	
4100302	SILTCOOS HEIGHTS	SILTCOOS LAKE			38863
4100302	**SILTCOOS HEIGHTS**	**SUBTOTAL**	**125**	**825**	**38863**

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100317	CITY OF GATES	NORTH SANTIAM RIVER		2624	
4100317	CITY OF GATES	NORTH SANTIAM RIVER			238707
4100317	**CITY OF GATES**	**SUBTOTAL**	**535**	**2624**	**238707**
4100323	CITY OF GLENDALE	COW CREEK		37197	
4100323	CITY OF GLENDALE	MILL CREEK		42	
4100323	CITY OF GLENDALE	SECTION CREEK		426	
4100323	CITY OF GLENDALE	COW CREEK			80664
4100323	CITY OF GLENDALE	MILL CREEK			429
4100323	CITY OF GLENDALE	SECTION CREEK			575
4100323	**CITY OF GLENDALE**	**SUBTOTAL**		**37665**	**81669**
4100324	KERNVILLE-GLENEDEN-LINCOLN BCH W D	DRIFT CREEK		1861	
4100324	KERNVILLE-GLENEDEN-LINCOLN BCH W D	DRIFT CREEK			20376
4100324	**KERNVILLE-GLENEDEN-LINCOLN BCH W D**	**SUBTOTAL**		**1861**	**20376**
4100326	GLIDE WATER ASSOCIATION	NORTH UMPQUA RIVER		60943	
4100326	GLIDE WATER ASSOCIATION	NORTH UMPQUA RIVER			367586
4100326	**GLIDE WATER ASSOCIATION**	**SUBTOTAL**	**900**	**60943**	**367586**
4100333	CITY OF GOLD HILL	ROGUE RIVER		34045	
4100333	CITY OF GOLD HILL	ROGUE RIVER			249777
4100333	**CITY OF GOLD HILL**	**SUBTOTAL**	**1,115**	**34045**	**249777**
4100342	CITY OF GRANTS PASS	ROGUE RIVER		69042	
4100342	CITY OF GRANTS PASS	ROGUE RIVER			101888
4100342	**CITY OF GRANTS PASS**	**SUBTOTAL**	**26,000**	**69042**	**101888**
4100359	CORBETT WATER DISTRICT	NORTH FORK GORDON CREEK		324	
4100359	CORBETT WATER DISTRICT	SOUTH FORK GORDON CREEK		46	
4100359	CORBETT WATER DISTRICT	NORTH FORK GORDON CREEK			1773
4100359	CORBETT WATER DISTRICT	SOUTH FORK GORDON CREEK			1761
4100359	**CORBETT WATER DISTRICT**	**SUBTOTAL**	**2910**	**370**	**3534**
4100379	HILLSBORO-FOREST GROVE-BEAVERTON	NORTH FORK TRASK RIVER (BARNEY RESERVOIR)		600	
4100379	HILLSBORO-FOREST GROVE-BEAVERTON	TUALATIN RIVER		2817	

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100379	HILLSBORO-FOREST GROVE-BEAVERTON	NORTH FORK TRASK RIVER (BARNEY RESERVOIR)			4681
4100379	HILLSBORO-FOREST GROVE-BEAVERTON	TUALATIN RIVER			112489
4100379	**HILLSBORO-FOREST GROVE-BEAVERTON**	**SUBTOTAL**	**65100**	**3416**	**117170**
4100408	CITY OF JEFFERSON	NORTH SANTIAM RIVER		30953	
4100408	CITY OF JEFFERSON	NORTH SANTIAM RIVER			223196
4100408	**CITY OF JEFFERSON**	**SUBTOTAL**	**2245**	**30953**	**223196**
4100466	LANGLOIS WATER DISTRICT	FLORAS CREEK		3099	
4100466	LANGLOIS WATER DISTRICT	FLORAS CREEK			35926
4100466	**LANGLOIS WATER DISTRICT**	**SUBTOTAL**	**250**	**3099**	**35926**
4100473	CITY OF LEBANON	SOUTH SANTIAM CANAL		4508	
4100473	CITY OF LEBANON	SOUTH SANTIAM CANAL			73732
4100473	**CITY OF LEBANON**	**SUBTOTAL**	**11000**	**4508**	**73732**
4100483	LINCOLN CITY WATER DISTRICT	SCHOONER CREEK		310	
4100483	LINCOLN CITY WATER DISTRICT	SCHOONER CREEK			9284
4100483	**LINCOLN CITY WATER DISTRICT**	**SUBTOTAL**	**13527**	**310**	**9284**
4100493	LYONS MEHAMA WATER DISTRICT	NORTH SANTIAM RIVER		15262	
4100493	LYONS MEHAMA WATER DISTRICT	NORTH SANTIAM RIVER			73059
4100493	**LYONS MEHAMA WATER DISTRICT**	**SUBTOTAL**	**1670**	**15262**	**73059**
4100497	MCMINNVILLE WATER AND LIGHT	HASKINS RESERVOIR		691	
4100497	MCMINNVILLE WATER AND LIGHT	MCGUIRE RESERVOIR		20	
4100497	MCMINNVILLE WATER AND LIGHT	HASKINS RESERVOIR			1235
4100497	MCMINNVILLE WATER AND LIGHT	MCGUIRE RESERVOIR			4259
4100497	**MCMINNVILLE WATER AND LIGHT**	**SUBTOTAL**	**2100**	**711**	**5494**

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100513	MEDFORD WATER COMMISSION	ROGUE RIVER		69729	
4100513	MEDFORD WATER COMMISSION	ROGUE RIVER			231481
4100513	**MEDFORD WATER COMMISSION**	**SUBTOTAL**	**83,454**	**69729**	**231481**
4100520	MILL CITY WATER DEPARTMENT	NORTH SANTIAM RIVER		1594	
4100520	MILL CITY WATER DEPARTMENT	NORTH SANTIAM RIVER			17810
4100520	**MILL CITY WATER DEPARTMENT**	**SUBTOTAL**	**1800**	**1594**	**17810**
4100534	CITY OF MOLALLA	MOLALLA RIVER		43125	
4100534	CITY OF MOLALLA	MOLALLA RIVER			86867
4100534	**CITY OF MOLALLA**	**SUBTOTAL**	**3100**	**43125**	**86867**
4100548	CLARKS BRANCH WTR. ASSOCIATION	SOUTH UMPQUA RIVER		31450	
4100548	CLARKS BRANCH WTR. ASSOCIATION	SOUTH UMPQUA RIVER			52653
4100548	**CLARKS BRANCH WTR. ASSOCIATION**	**SUBTOTAL**	**140**	**31450**	**52653**
4100549	TRI-CITY WATER DISTRICT	SOUTH UMPQUA RIVER		36492	
4100549	TRI-CITY WATER DISTRICT	SOUTH UMPQUA RIVER			70005
4100549	**TRI-CITY WATER DISTRICT**	**SUBTOTAL**	**3500**	**36492**	**70005**
4100550	CITY OF MYRTLE CREEK	SOUTH UMPQUA RIVER		424	
4100550	CITY OF MYRTLE CREEK	SPRINGBROOK SPRINGS A		100	
4100550	CITY OF MYRTLE CREEK	SPRINGBROOK SPRINGS B		67	
4100550	CITY OF MYRTLE CREEK	SOUTH UMPQUA RIVER			3804
4100550	CITY OF MYRTLE CREEK	SPRINGBROOK SPRINGS A			187
4100550	CITY OF MYRTLE CREEK	SPRINGBROOK SPRINGS B			228
4100550	**CITY OF MYRTLE CREEK**	**SUBTOTAL**	**3,460**	**591**	**4219**
4100551	CITY OF MYRTLE POINT	NORTH FORK COQUILLE RIVER		81975	
4100551	CITY OF MYRTLE POINT	NORTH FORK COQUILLE RIVER			98932
4100551	**CITY OF MYRTLE POINT**	**SUBTOTAL**	**2715**	**81975**	**98932**
4100581	CITY OF OAKLAND	CALAPOOYA CREEK		5056	

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100581	CITY OF OAKLAND	CALAPOOYA CREEK			59857
4100581	**CITY OF OAKLAND**	**SUBTOTAL**	**954**	**5056**	**59857**
4100603	PANTHER CREEK WATER DISTRICT	PANTHER CREEK		35	
4100603	PANTHER CREEK WATER DISTRICT	PANTHER CREEK			1071
4100603	**PANTHER CREEK WATER DISTRICT**	**SUBTOTAL**	**550**	**35**	**1071**
4100624	CITY OF PHILOMATH PUBLIC WORKS	MARY'S RIVER		1084	
4100624	CITY OF PHILOMATH PUBLIC WORKS	MARY'S RIVER			84926
4100624	**CITY OF PHILOMATH PUBLIC WORKS**	**SUBTOTAL**	**4000**	**1084**	**84926**
4100657	PORTLAND BUREAU OF WATER WORKS	BULL RUN		60	
4100657	PORTLAND BUREAU OF WATER WORKS	BULL RUN			65523
4100657	**PORTLAND BUREAU OF WATER WORKS**	**SUBTOTAL**	**831000**	**60**	**65523**
4100672	CITY OF POWERS	BINGHAM CREEK		16	
4100672	CITY OF POWERS	SOUTH FORK COQUILLE RIVER		234	
4100672	CITY OF POWERS	BINGHAM CREEK			163
4100672	CITY OF POWERS	SOUTH FORK COQUILLE RIVER			93877
4100672	**CITY OF POWERS**	**SUBTOTAL**	**700**	**250**	**94039**
4100706	CITY OF RIDDLE	COW CREEK		83338	
4100706	CITY OF RIDDLE	COW CREEK			109130
4100706	**CITY OF RIDDLE**	**SUBTOTAL**	**1,303**	**83338**	**109130**
4100707	LAWSON ACRES WATER ASSOCIATION	COW CREEK		2363	
4100707	LAWSON ACRES WATER ASSOCIATION	COW CREEK			4661
4100707	**LAWSON ACRES WATER ASSOCIATION**	**SUBTOTAL**	**75**	**2363**	**4661**
4100712	CITY OF ROGUE RIVER	ROGUE RIVER		25273	
4100712	CITY OF ROGUE RIVER	ROGUE RIVER			43689
4100712	CITY OF ROGUE RIVER	SUBTOTAL	2000	25273	43689
4100717	ROBERTS CREEK WATER DISTRICT	SOUTH UMPQUA RIVER			3095

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100717	**ROBERTS CREEK WATER DISTRICT**	**SUBTOTAL**	**6500**	**0**	**3095**
4100719	UMPQUA BASIN WATER ASSOCIATION	NORTH UMPQUA RIVER		1214	
4100719	UMPQUA BASIN WATER ASSOCIATION	NORTH UMPQUA RIVER			32269
4100719	**UMPQUA BASIN WATER ASSOCIATION**	**SUBTOTAL**	**8500**	**1214**	**32269**
4100720	CITY OF ROSEBURG-WINCHESTER	NORTH UMPQUA RIVER		24682	
4100720	CITY OF ROSEBURG-WINCHESTER	NORTH UMPQUA RIVER			106472
4100720	**CITY OF ROSEBURG-WINCHESTER**	**SUBTOTAL**	**30000**	**24682**	**106472**
4100731	SALEM PUBLIC WORKS	NORTH SANTIAM RIVER AND IG		934	
4100731	SALEM PUBLIC WORKS	NORTH SANTIAM RIVER AND IG			16221
4100731	**SALEM PUBLIC WORKS**	**SUBTOTAL**	**170000**	**934**	**16221**
4100789	CITY OF SANDY	ALDER CREEK		633	
4100789	CITY OF SANDY	ALDER CREEK			3769
4100789	**CITY OF SANDY**	**SUBTOTAL**	**5030**	**633**	**3769**
4100792	CITY OF SCAPPOOSE	GOURLAY		550	
4100792	CITY OF SCAPPOOSE	LAZY CREEK		377	
4100792	CITY OF SCAPPOOSE	SOUTH FORK SCAPPOOSE CREEK		1477	
4100792	CITY OF SCAPPOOSE	GOURLAY			879
4100792	CITY OF SCAPPOOSE	LAZY CREEK			337
4100792	CITY OF SCAPPOOSE	SOUTH FORK SCAPPOOSE CREEK			2413
4100792	**CITY OF SCAPPOOSE**	**SUBTOTAL**	**3500**	**2404**	**3629**
4100808	COUNTRY VIEW MH ESTATES	ROGUE RIVER		94370	
4100808	COUNTRY VIEW MH ESTATES	ROGUE RIVER			639475
4100808	**COUNTRY VIEW MH ESTATES**	**SUBTOTAL**	**112**	**94370**	**639475**
4100811	CITY OF SHERIDAN	SOUTH YAMHILL RIVER		14950	
4100811	CITY OF SHERIDAN	SOUTH YAMHILL RIVER			120465
4100811	**CITY OF SHERIDAN**	**SUBTOTAL**	**5200**	**14950**	**120465**
4100821	CITY OF SILETZ	SILETZ RIVER		13670	

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100821	CITY OF SILETZ	TANGERMAN CREEK		1	
4100821	CITY OF SILETZ	SILETZ RIVER			117918
4100821	CITY OF SILETZ	TANGERMAN CREEK			296
4100821	**CITY OF SILETZ**	**SUBTOTAL**	**1100**	**13671**	**118214**
4100823	CITY OF SILVERTON	ABIQUA CREEK		1776	
4100823	CITY OF SILVERTON	ABIQUA CREEK			29894
4100823	**CITY OF SILVERTON**	**SUBTOTAL**	**5480**	**1776**	**29894**
4100843	STAYTON WATER SUPPLY	NORTH SANTIAM RIVER		0	
4100843	STAYTON WATER SUPPLY	NORTH SANTIAM RIVER			4537
4100843	**STAYTON WATER SUPPLY**	**SUBTOTAL**	**5630**	**0**	**4537**
4100847	CITY OF SUTHERLIN	CALAPOOYA CREEK NON-PAREIL		5055	
4100847	CITY OF SUTHERLIN	COOPER CREEK		480	
4100847	CITY OF SUTHERLIN	CALAPOOYA CREEK NON-PAREIL			49629
4100847	CITY OF SUTHERLIN	COOPER CREEK			2456
4100847	**CITY OF SUTHERLIN**	**SUBTOTAL**	**6360**	**5535**	**52086**
4100851	CITY OF SWEET HOME	SOUTH SANTIAM RIVER		31600	
4100851	CITY OF SWEET HOME	SOUTH SANTIAM RIVER			329872
4100851	**CITY OF SWEET HOME**	**SUBTOTAL**	**7235**	**31600**	**329872**
4100926	CITY OF WALDPORT	ECKMAN CREEK		40	
4100926	CITY OF WALDPORT	NORTH FORK WEIST CREEK		29	
4100926	CITY OF WALDPORT	ECKMAN CREEK			2756
4100926	CITY OF WALDPORT	NORTH FORK WEIST CREEK			169
4100926	CITY OF WALDPORT	SOUTH FORK WEIST CREEK			193
4100926	**CITY OF WALDPORT**	**SUBTOTAL**	**3000**	**69**	**3118**
4100953	CITY OF WILLAMINA WATER DEPARTMENT	WILLAMINA CREEK		15010	
4100953	CITY OF WILLAMINA WATER DEPARTMENT	WILLAMINA CREEK			37480
4100953	**CITY OF WILLAMINA WATER DEPARTMENT**	**SUBTOTAL**	**1760**	**15010**	**37480**
4100957	WINSTON-DILLARD WATER DISTRICT	SOUTH UMPQUA RIVER		28316	
4100957	WINSTON-DILLARD WATER DISTRICT	SOUTH UMPQUA RIVER			83243

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4100957	**WINSTON-DILLARD WATER DISTRICT**	**SUBTOTAL**	**6500**	**28316**	**83243**
4100958	CITY OF YONCALLA	ADAMS CREEK		494	
4100958	CITY OF YONCALLA	ADAMS CREEK			709
4100958	CITY OF YONCALLA	WILSON CREEK			474
4100958	**CITY OF YONCALLA**	**SUBTOTAL**	**1095**	**494**	**1183**
4100968	CITY OF YAMHILL	TURNER CREEK		963	
4100968	CITY OF YAMHILL	TURNER CREEK			1955
4100968	**CITY OF YAMHILL**	**SUBTOTAL**	**1500**	**963**	**1955**
4100971	CITY OF CAVE JUNCTION	EAST FORK ILLINOIS RIVER		15476	
4100971	CITY OF CAVE JUNCTION	EAST FORK ILLINOIS RIVER			107511
4100971	**CITY OF CAVE JUNCTION**	**SUBTOTAL**	**1,440**	**15476**	**107511**
4100985	HILLSBORO-CHERRY GROVE	TUALATIN RIVER		952	
4100985	HILLSBORO-CHERRY GROVE	TUALATIN RIVER			14613
4100985	**HILLSBORO-CHERRY GROVE**	**SUBTOTAL**	**250**	**952**	**14613**
4101092	USFS TILLER RANGER STATION	USFS TILLER RANGER STATION		10566	
4101092	USFS TILLER RANGER STATION	USFS TILLER RANGER STATION			277963
4101092	**USFS TILLER RANGER STATION**	**SUBTOTAL**	**1092**	**10566**	**277963**
4101095	USFS WOLF CREEK JOB CORPS	LITTLE RIVER		2405	
4101095	USFS WOLF CREEK JOB CORPS	LITTLE RIVER			55405
4101095	**USFS WOLF CREEK JOB CORPS**	**SUBTOTAL**	**250**	**2405**	**55405**
4101174	BUELL-RED PRAIRIE WATER ASSN	GOOSENECK CREEK		959	
4101174	BUELL-RED PRAIRIE WATER ASSN	GOOSENECK CREEK			98
4101174	**BUELL-RED PRAIRIE WATER ASSN**	**SUBTOTAL**	**980**	**959**	**98**
4190416	FORT JAMES OPERATING CO.	COLUMBIA RIVER		819	
4190416	FORT JAMES OPERATING CO.	COLUMBIA RIVER			86153
4190416	**FORT JAMES OPERATING CO.**	**SUBTOTAL**	**750**	**819**	**86153**

PWS_ID[1]	PWS Name	Source	Population Served	BLM Acres	Other Acres
4192139	TILLER ELEMENTARY, SD #15	SOUTH UMPQUA RIVER		386	
4192139	TILLER ELEMENTARY, SD #15	SOUTH UMPQUA RIVER			54592
4192139	**TILLER ELEMENTARY, SD #15**	**SUBTOTAL**	**60**	**386**	**54592**
4192152	POPE & TALBOT, INC.,	WILLAMETTE RIVER		77011	
4192152	POPE & TALBOT, INC.,	WILLAMETTE RIVER			1167276
4192152	**POPE & TALBOT, INC.,**	**SUBTOTAL**	**800**	**77011**	**1167276**
4192674	USFS STAR RANGER STATION	APPLEGATE RIVER		4402	
4192674	USFS STAR RANGER STATION	APPLEGATE RIVER			115722
4192674	**USFS STAR RANGER STATION**	**SUBTOTAL**	**25**	**4402**	**115722**
4194300	ROSEBURG FOREST PROD-DILLARD	SOUTH UMPQUA RIVER		3823	
4194300	ROSEBURG FOREST PROD-DILLARD	SOUTH UMPQUA RIVER			25041
4194300	**ROSEBURG FOREST PROD-DILLARD**	**SUBTOTAL**	**2000**	**3823**	**25041**

[1] Department of Environmental Quality Public Water System identification number for surface drinking water watersheds.

Best Management Practices

Introduction

A Best Management Practice or BMP is a practice, or combination or practices that have been determined to be the most effective and practicable in preventing or reducing the amount of pollution generated by diffuse sources to a level compatible with water quality goals (40 CFR 130.2 [m]).

Best Management Practices are a type of water pollution control. This section defines the best management practices (i.e., methods and measures) that were developed for the lands within the western Oregon planning area to comply with the requirements of the Clean Water Act.

Purpose

Best management practices (BMPs) are required by the federal Clean Water Act, as amended to reduce nonpoint source pollution to the maximum extent practicable. Nonpoint source pollution is pollutants detected in a concentrated water source such as a stream, or lake that come from a wide range of forest and range activities. The BMPs are considered the primary controls for achieving Oregon's water quality standards. Oregon's narrative criteria, which include numeric standards, are designed to protect designated beneficial uses (such as salmonid spawning and raring, resident fish and aquatic life, domestic water supplies, and water-contact recreation).

The BMPs are methods, measures, or practices selected on the basis of site-specific conditions to ensure that water quality will be maintained at its highest practicable level. The BMPs include, but are not limited to, avoidance, structural and nonstructural treatments, operations, and maintenance procedures. Although normally preventative, BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (40 CFR 130.2, EPA Water Quality Standards Regulation).

Organization and Use

The BMPs in this appendix are organized by the following management activities:

- roads and landings
- timber harvest activities
- silvicultural activities
- fire and fuels management
- surface source water for drinking water
- recreation
- grazing
- minerals exploration and development
- spill prevention and abatement
- restoration

The tables that follow this introduction identify the input variables, causal mechanisms, and water quality standards (referenced by the Oregon Administrative Rules number) that are associated with each BMP.

Those BMPs that are necessary for typical situations have been included. When applied, BMPs are expected to prevent water quality degradation and to meet water quality standards.

Causal mechanisms help explain the outcomes or the process through which an outcome occurs.

Resource aspects of land management activities normally have many facets that require site-specific BMP design. Therefore, there may be some repetition of the BMPs between sections of the following tables. An activity may use an individual BMP, whereas another activity may involve BMPs in combination from several sections for water quality protection.

Management of locatable minerals is governed by regulations found in 43 CFR 3809. The BMPs for locatable minerals include language from 43 CFR 3809 that requires operators to prevent unnecessary and undue degradation from mining operations.

Some BMPs that relate to instream activities may coincidently be similar to applicable practices specified in Army Corps of Engineers, Department of State Lands, and ODFW joint removal/fill permits, DEQ water quality permits and 401 certifications, or project design criteria contained in biological assessments. The BMPs in the following tables are not specific permit requirements, but rather demonstrate the process by which nonpoint source pollution from instream activities would be controlled.

The BMPs are practices, techniques, or management strategies that have been evaluated through common practice or studies, and shown to be an effective and practical means of preventing or reducing nonpoint source pollution. The BMPs are not intended to serve as detailed engineering specifications or design criteria. Such specifications are available for field use from various sources.

Application of Best Management Practices

Selection of BMPs are made by soil, water, fisheries, geology and other professionals during project-level analyses. It is not intended that all of the BMPs listed will be selected for any specific management action. Each activity is unique, based on site-specific conditions, and the selection of an individual BMP or a combination of BMPs and measures becomes the BMP design.

The BMPs must be applied in a manner that is consistent with all Resource Management Plan objectives. The overall goal is not to adhere strictly to a particular set of BMPs, but to meet water quality objectives when implementing management actions. Describing non-point pollution causal mechanisms allows specialists to exercise discretion as to what will work best in a particular situation. An example is the need to respond to a wide range of geology, landform, soils, watershed characteristics and climate. Although this appendix does not provide an exhaustive list of BMPs, the included BMPs are believed to cover most project activity situations in the Plan area. Additional nonpoint source control measures may be identified during the interdisciplinary process when evaluating site-specific management actions.

Where found to be ineffective, BMPs may require modification to meet water quality objectives. Specialists may consider baseline environmental conditions, type of activity, proximity to water, disturbance level, direct, indirect, and cumulative effects and timing. They may also evaluate new technology and relevant implementation or effectiveness monitoring data, published studies or other sources of information, in refining existing BMPs or recommending new BMPs. This process involves continued learning and applying monitoring feedback.

Review and update of this appendix , including BMP corrections or additions that are derivatives of existing BMPs, would be completed through plan maintenance.

Roads and Landings

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-17. Best Management Practices For Roads And Landings

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 1	Locate roads and landings on stable locations that minimize sediment delivery potential to streams (e.g., ridge tops, stable benches or flats, and gentle-to-moderate side-slopes). To the extent workable, avoid unstable headwalls, and steep channel-adjacent side slopes.	Coarse and Fine Sediment, and Organic Debris: Failures from roads built across unstable landforms that may slide into stream channels Coarse and Fine Sediment: Alters channel form, which warms stream temperatures due to either increased widening or deepening (incising) channels becoming disconnected from the flood plain hyporheic zone	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Temp OAR 340-041-0028 Turbidity OAR 340-041-0036
R 2	Where practical to do so, plan routes to limit new road construction, including stream crossings, within riparian management areas.	Coarse and Fine Sediment: Surface erosion due to lack of adequate vegetative cover, or nearness to stream channels that may deliver. Temperature: Roads located adjacent to streams, causing opening in forest canopy that may reduce local stream shade.	Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
R 3	Considering topographic and safety constraints, locate roads so as to lower cutbank heights and cutbank slope angles, where ditchlines could deliver run-off directly to stream channels.	Coarse and Fine Sediment: Erosion from exposed soils on cut banks	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 4	Locate roads and landings outside of jurisdictional wetlands.	Coarse and Fine Sediment: Surface erosion or ravel, due to lack of adequate vegetative cover, or nearness to stream channels that may deliver	Antidegradation OAR 340-04l-0004 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 5	To the extent workable, locate new landings outside of Riparian Management Areas. Avoid expanding existing landings in Riparian Management Areas where sediment delivery to stream channels could occur.	Coarse and Fine Sediment, and Temperature: Surface erosion or ravel, due to lack of adequate vegetative cover or nearness to stream channels that may deliver Temperature: Increase landing size or shape, causing opening in forest canopy that may reduce local stream shade	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
R 6	Locate landings in areas with low risk for landslides.	Coarse and Fine Sediment, and Organic Debris: Failures from landings sited on unstable landforms that may slide into stream channels	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 7	Locate excavated material disposal areas outside Riparian Management Areas, floodplains, and unstable areas that could transport sediment to waterbodies.	Coarse and Fine Sediment: Surface erosion or ravel, due to lack of adequate vegetative cover, or nearness to stream channels that may deliver	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
		General Construction	
R 8	Design roads no wider than needed for the specific use.	Coarse and Fine Sediment: Surface erosion from wet weather, due to lack of adequate vegetative cover that may deliver to a stream channel	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 9	Limit road and landing construction, reconstruction, or renovation activities to the dry season, generally from May into October. When conditions permit operations outside of the dry season, keep erosion control measures concurrent with ground disturbance to the extent that the affected area can be rapidly stormproofed if weather conditions deteriorate.	Coarse and Fine Sediment: Surface erosion from wet weather, due to lack of adequate vegetative cover that may deliver to a stream channel	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 10	End-haul excavated material to minimize side-casting of waste material if side slopes generally exceed 60 percent, or where side-cast material may enter waterbodies, wetlands, or floodplains.	Coarse and Fine Sediment, and Organic Debris: Fill run-out or failures from roads built across steep landforms that may slide into stream channels	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 11	Conduct pioneer road construction to avoid the deposition of materials in waterbodies, floodplains, or wetlands.	Coarse and Fine Sediment: Pioneer road construction earthwork, with some downslope movement or drifting of unconsolidated soil medium towards waterbodies, floodplains, or wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 12	Use controlled blasting techniques.	Coarse and Fine Sediment: Blasting with radial movement of unconsolidated soil medium or rock fragments, towards waterbodies, floodplains, or wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 13	Use only soil and rock materials in permanent road fills. Build up fills by layering; (e.g. 6 inch lifts) compact between 85 and 95 percent maximum density using compaction equipment. Provide for additional fill drainage (e.g. use geo-textile fabrics, etc.) in landslide prone areas.	Coarse and Fine Sediment, and Organic Debris: Failures from roads with inadequate fill construction, or without proper drainage, that may slide into stream channels	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 14	Where deemed necessary, use temporary sediment containment structures to contain runoff from construction areas (e.g. silt fencing).	Coarse and Fine Sediment: New earthwork, lacking vegetative cover, that may erode and deliver to waterbodies, floodplains, or wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 15	Surface roads if they would be subject to traffic during prolonged wet weather.	Coarse and Fine Sediment: Road tread erosion, increased by traffic, especially during wet weather on susceptible soil types, causing rilling or rutting, and delivery to a stream channel	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 16	Complete construction activities prior to fall rains. Prevent erosion in areas with direct connectivity to streams by stabilizing exposed soil materials.	Coarse and Fine Sediment: Vegetative and organic ground cover, decreasing soil detachment, transport and delivery to stream channels	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 17	Seed and mulch cut and fill slopes, ditchlines, and waste disposal upon construction completion. Where straw mulch or rice straw mulch is used; require certified weed free, if readily available. Mulch shall be applied at no less than 2000 lbs/acre	Coarse and Fine Sediment: Vegetative and organic ground cover, decreasing soil detachment, transport and delivery to stream channels	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 18	For new road construction, clear channels and ditches of excess sediment and debris above culvert inlets prior to fall rains.	Coarse and Fine Sediment: Culvert inlets becoming plugged with sediment or floatable organic debris, resulting in water ponding against the road fill, and headcutting and loss of the fill at the crossing or diversion and/or gullying down the road ditchline and loss of the road fill at another site, with sediment delivery to waterbodies, floodplains, or wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 19	Correct special drainage problems (e.g., high water table, seeps) that effect stability of the road subgrade through the use of perforated drains, geotextiles, or drainage bays.	Coarse and Fine Sediment: Saturated fills or wet areas that could fail or erode and deliver sediment to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 20	Conduct slope rounding on tops of cut slopes in clayey soils to reduce sloughing and surface ravel.	Coarse and Fine Sediment: Erosion from exposed soils on cut and fill slopes. Road tread erosion, increased by traffic, especially during wet weather on susceptible soil types, causing rilling or rutting, and delivery to a stream channel.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007 (1)&(13) Turbidity OAR 340-041-0036
R 21	Where sediment would be transported to streams, consider windrowing slash at the base of newly constructed fill slopes to catch sediment.	Coarse and Fine Sediment: Erosion from exposed soils on cut and fill slopes. Road tread erosion, increased by traffic, especially during wet weather on susceptible soil types, causing rilling or rutting, and delivery to a stream channel.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007 (1)&(13) Turbidity OAR 340-041-0036
Surface Drainage			
R 22	Drain the road surface by using crowning, insloping or outsloping. Road surfaces, regardless of traffic volume, may use a combination of these methods for effective road drainage into nonerodible areas.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 23	Low traffic roads should be outsloped, unless there is a traffic hazard from the road shape. Roads can be insloped for specific purposes, such as to drain unstable areas or where the underlying formation is very rocky and not erodible.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 24	Out-slope low traffic volume roads to provide surface drainage on road gradients up to 8 percent, where an inside ditch is not planned.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 25	Use rolling drainage dips and/or lead-off ditches as options in lieu of culverts for low traffic volume roads with less than 10 percent gradient.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 26	Locate surface water drainage measures (water bars, rolling dips, etc.) where they will drain the road surface without delivering sediment to a stream or waterbody, and at frequencies that are sufficient to prevent damage or serious erosion of the road surface. Install during the dry season.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 27	Outside road berms are discouraged. Where there is an outside berm that prevents water from exiting the roadway, it should be breached at intervals to prevent accumulation of water and delivery of sediment to streams and waterbodies.	Coarse and Fine Sediment: Concentrated water flows during storm events from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 28	Roll the grade in erodible and unstable soils to reduce surface water volume and velocities.	Coarse and Fine Sediment: Concentrated water flows from compacted road surfaces that may travel longer distances, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 29	Divert road and landing runoff water away from headwalls, unstable areas or stream channels.	Coarse and Fine Sediment: Water volume concentration resulting in headwall saturation with possible failures to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 30	Shape landings to spread surface water runoff to well- vegetated, stable ground.	Coarse and Fine Sediment: Concentrated water flows from compacted landing surfaces that may travel longer distances, entering waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 31	Prevent diversion of water from streams into road ditches or upon road surfaces.	Coarse and Fine Sediment: Concentrated water flow from streams causing ditch erosion, and sediment delivery to another stream channel. Dewatering of a stream channel with negative effects on fishes and aquatic life.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007 (1)&(13) Turbidity OAR 340-041-0036
R 32	For roads involving very erodible soils near streams: • Where possible, outsloping should be the preferred road drainage treatment. • Construct lead-in ditch to catchbasins • Require rock armoring of lead-in ditch for through fills greater than 6 feet in height • Design catch basins in a manner that would settle out transported sediments. Maintain these catch basins.	Coarse and Fine Sediment: Concentrated water flow from roads and subsequent soil movement to streams	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007 (1)&(13) Turbidity OAR 340-041-0036
	Cross Drains		
R 33	Locate cross drains such that runoff and sediment is not discharged to a stream. Use measures such as ditchline settling basins, culvert endcaps and perforated flex pipes on the discharge end of stream relief culverts to disperse culvert discharge near streams and waterbodies.	Coarse and Fine Sediment: Road water and sediment draining directly into waterbodies, causing water quality degradation.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 34	Space cross drains at intervals sufficient to prevent water volume concentration and accelerated ditch erosion. Increase cross drain frequency through through erodible soils, steep grades, and unstable areas.	Coarse and Fine Sediment: Water volume concentration, resulting greater erosive energy, rilling and gullying road ditchlines and delivery to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 35	Cross drainage culverts should be a minimum of 18 inches in diameter. If flex pipes are used, care should be taken during installation so as to avoid reducing pipe diameter.	Coarse and Fine Sediment: Cross drain restricted size that can plug with sediments and debris, causing water flow volume concentration in ditchlines resulting in gullying with materials delivered to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 36	Construct cross drainage culverts or drainage dips at nearest and best available location upgrade of stream crossings to prevent ditchflow and sediment from entering the stream.	Coarse and Fine Sediment: Concentrated ditch flow from storm events or snowmelt, causing erosion of the ditchline or carrying sediment sloughed from the cutbank, that if left unchecked may deliver to a stream channel	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 37	Site cross drains to exit on convex slopes and avoid discharge onto erodible and/or unstable ground, (such as headwalls, slumps, or block failure zones), or directly into stream channels. Provide a buffer or sediment basin between the cross drain outlet and waterbodies, floodplains, or wetlands.	Coarse and Fine Sediment: Water volume concentration, resulting in headwall saturation with possible failures to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 38	Armor drainage dips to maintain functionality in areas of erosive soils that are subject to rapid erosion by runoff.	Coarse and Fine Sediment: Concentrated water flows from compacted road surfaces that may erode and gully in susceptible soils, entering ditchlines, and waterbodies.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 39	Install downspout structures and/ or energy dissipators (e.g., rock material) at cross drain outlets or drain dips where water is discharged onto loose material or erodible soils, fills, or steep slopes.	Coarse and Fine Sediment: Concentrated ditch flow from storm events or snowmelt, causing erosion of the ditchline or carrying sediment sloughed from the cutbank that if left unchecked, may deliver to a stream channel	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 40	Extend culvert outlets or downspout structures onto undisturbed ground.	Surface water from compacted surfaces saturating road fills with possible slumping or mass failure and delivery to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 41	Cut protruding “cannon” culverts at the fill surface, install downspout and/or energy dissipators on erodible fills.	Coarse and Fine Sediment: Surface water from compacted surfaces saturating road fills with possible slumping or mass failure and delivery to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 42	Where erosion of road fill is occurring at cross-drain entrance, either add more cross-drains along ditchline to reduce flow, or angle cross-drains near 30 degree angle to the road.	Coarse and Fine Sediment: Scour of road fills from too much water volume concentration, causing erosion and sediment delivery to waterbodies, floodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 43	Where debris or sediments may plug cross-drains, use slotted risers, over-sized culverts or build catch basins.	Coarse and Fine Sediment: Culvert plugging causing road fill failure and slug injections of sediments to waterbodies, loodplains and wetlands	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
	Stream Crossings (General)		
R 44	Install all crossings during the low flow period, generally from June 15 to September 15.	Coarse and Fine Sediment: Turbidity and sediment movement downstream during periods of low turbidities with possible effects on aquatic ife	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
	Permanent Stream Crossings		
R 45	Size culverts, bridges, and other stream crossings for the 100-year flood event including allowance for bed load and small floatable debris without exceeding capacity or diversion. Match culvert width with bankfull channel width.	Coarse and Fine Sediment, and Organic Debris: Floodwaters exceeding pipe capacity, causing overtopping of pipe and fills, with ensuing headcutting and loss of road fill.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 46	To the extent workable, limit the number of new stream crossings, by evaluating practical upland alternatives.	Coarse and Fine Sediment: Turbidity and sediment entry of road run-off to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 47	Construct the stream crossing approach to minimize fill volumes and sediment delivery potential.	Coarse and Fine Sediment: Earthwork near waterbodies, floodplains and wetlands causing sediment delivery.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 48	Locate culvert placement on a well defined, unobstructed, and straight reach of stream. Where a bend in the channel cannot be avoided, or would have less impact than moving the road elsewhere, place the alignment of the culvert with the upstream channel and armor the discharge side of the culvert into an erodible bank.	Coarse and Fine Sediment: Earthwork near waterbodies, floodplains and wetlands causing sediment delivery.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 49	Where workable, install culverts in intermittent channels at the natural stream grade.	Coarse and Fine Sediment: Floodwater piping or eroding unconsolidated road fill, causing failures with sediment delivery to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 50	When installing stream culverts, divert the stream around the work area with coffer dams, pumping etc.. Maintain diversion until all instream work is completed. Pump seepage water that may escape the containment to an off-stream filtration area.	Coarse and Fine Sediment: Erosion at the instream construction site causing sediment movement downstream during periods of low turbidities with possible effects on aquatic life.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 51	Use containment and filtering techniques such as bladder barriers, silt curtains etc if diversion is not possible. Place sediment controls along and immediately downstream of the instream work.	Coarse and Fine Sediment: Sediment movement downstream during periods of low turbidities with possible effects on aquatic life.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 52	To the extent workable, limit activities of mechanized equipment to streambank areas or temporary platforms when installing or removing structures.	Coarse and Fine Sediment, Oil, and Toxins: Erosion at the instream construction site causing turbidity and sediment movement downstream	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 53	Use stream crossing protection such as hardened crossing, fill armoring, grade dipping, etc. where high debris loads are expected (such as debris torrent channels) to allow overflow without loss of the fill or diversion of streamflow.	Coarse and Fine Sediment,and Organic Debris: Debris flows plugging culverts or removing road fills with high delivery of sediments and materials to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 54	Provide adequate stream bank protection using bioengineering techniques e.g., live plants or cuttings, dead plant material, rock or other inert structure where bank erosion would occur.	Coarse and Fine Sediment: Stream scour of road fill, causing entrainment of sediment in flowing water and delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 55	Provide structural erosion control measures e.g., riprap, wing walls, etc. on erosion-prone fills, inlets, and outlets.	Coarse and Fine Sediment: Scour of streambed at culvert outlet, causing entrainment of sediment in flowing water and delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 56	Where channels are not naturally armored, place energy dissipators e.g., large rock at the outlet of culverts on streams.	Coarse and Fine Sediment: Stream scour of road fill, causing entrainment of sediment in flowing water and delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 57	Stabilize fill material over stream crossing structures immediately after construction has been completed, normally before October 15. Exposed soils would be seeded and mulched. Temporarily suspend construction activity if rain saturates soils to the extent that there is potential for movement of sediment from the road to the stream. Soils must be covered or temporarily stabilized during work suspension.	Coarse and Fine Sediment: Surface erosion with sediment delivery to waterbodies, floodplains and wetlands.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 58	Incorporate additional design criteria (e.g., rock blankets, buttressing, relief pipes higher in the fill, etc.) for deep fills to lesson the susceptibility of fill failures.	Coarse and Fine Sediment, and Organic Debris: Floodwaters exceeding pipe capacity, causing overtopping of pipe, possible piping through fills with possible collapse or overtopping, with ensuing headcutting, loss of road fill, and possible dam break flood scouring downstream reaches.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 59	Use beveled culvert inlets, wingwalls, over-sized culverts, trash racks or in some cases slotted risers to prevent culvert plugging and failure in areas of active debris movement.	Coarse and fine Sediment, and Organic Debris: Mobile debris and materials plugging culverts with overtopping and failure of the road fill, and possible dam break flood, scouring downstream reaches.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 60	Install permanent stream crossing structures before heavy equipment moves beyond the crossing area. Where this is not feasible, install temporary crossings.	Coarse and Fine Sediment: Sediment movement downstream during periods of low turbidities with possible effects on aquatic life.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
Temporary Stream Crossings for Roads and Skid Trails			
R 61	To the extent workable, limit the use of mechanized equipment to streambank areas or temporary platforms when installing or removing structures. Avoid driving of mechanized equipment in the stream channel except in the area that is necessary for installation and removal operations.	Coarse and fine Sediment, Oil, and Toxins: Vehicles wheel tracks breaking down banks, to access stream channel bottoms, driving through stream water column, disturbing fish habitat, with possible release of oil, and asbestos from brake linings and similar toxins.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Statewide Narrative Criteria Toxics OAR 340-041-0007 Turbidity OAR 340-041-0036
R 62	Limit the number of new temporary crossings on a stream.	Coarse and Fine Sediment: Sediment movement downstream during periods of low turbidities with possible effects on aquatic life.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 63	Use washed river rock or crushed rock over geo-textile fabric, as s backfill material over temporary culverts, except where excessive displacement would occur from vehicle travel.	Coarse and Fine Sediment: Higher than anticipated streamflows, washing over or through temporary road crossing.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 64	Use the least amount of fill possible to facilitate the temporary stream crossing structure if a non- fill structure is not possible.	Coarse and Fine Sediment: Higher than anticipated streamflows, washing over or through temporary road crossing.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 65	Limit the installation and removal of temporary crossing structures within the prescribed work period where possible. Follow practices under the Closure/ Decommissioning section for removing stream crossing drainage structures and reestablishing natural drainage configuration.	Coarse and Fine Sediment: Fall or winter streamflows washing over temporary road and high stream energies washing a portion or all of the crossing downstream.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
Low-Water Ford Stream Crossings			
R 66	Use structures that would withstand 100-year flow events e.g., concrete, well anchored concrete mats, etc. on permanent crossings.	Coarse and Fine Sediment, and Toxins: High streamflow undermining or twisting structure, with possible channel shifts, and partial collapse or loss of structure.	Statewide Narrative Criteria Toxics OAR 340-041-0007 Turbidity OAR 340-041-0036
R 67	Harden approaches with non-erodible materials on permanent crossings. Provide relief drainage on approaches.	Coarse and Fine Sediment, and Toxins: Loose road surfacing, washing into the stream during storms.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 68	Use washed rock or gravel in temporary crossings, where a non-fill structure is not possible.	Coarse and Fine Sediment: Higher than anticipated streamflows, washing over or through temporary road crossing.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 69	Restrict unauthorized access to low-water ford stream crossings.	Coarse and Fine Sediment, Bacteria and Pathogens, Oil, and Toxins: Vehicular traffic, breaking down banks, disturbing stream substrate, causing turbidity and stream sedimentation. Driving through water column with possible contamination of waters with oils and toxics, bacteria and noxious weeds, washed from vehicle or tires.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Statewide Narrative Criteria Toxics OAR 340-041-0007 Turbidity OAR 340-041-0036
R 70	Use ramped low water fords in debris flow susceptible streams.	Coarse and Fine Sediment: Debris flows piling against road fills, plugging culverts and overtopping and loss of road prism, or dam break flood wave scouring downstream habitat.	Turbidity OAR 340-041-0036
Road Use and Dust Abatement			
R 71	Apply durable rock surfacing to withstand expected loads and traffic volume, and season of use.	Coarse and Fine Sediment: Road rock breaking down to fines, and washing from roads to ditchlines to stream channels.	Turbidity OAR 340-041-0036
R 72	For winter hauling implement structural treatments such as: adjust frequency of cross-drain spacing, install sediment barriers or catch basins, apply gravel lifts or asphalt road surfacing at stream crossing approaches, and clean and armor ditchlines.	Coarse and Fine Sediment: Road ditchlines gaining water volume concentration, transporting soil material to stream channels, or sediment sources near channels that can flow overland during storms by sheetwash or rill erosion, depositing soil material into stream channels.	Turbidity OAR 340-041-0036
R 73	Suspend timber hauling during wet weather when road run-off delivers sediment at higher concentrations than existing conditions in the receiving stream. Hauling could resume when ditch flow subsides, or when conditions allow turbidity standards to be met.	Coarse and Fine Sediment: Road erosion with potential transport to the channel and floodplain.	Turbidity OAR 340-041-0036
R 74	Remove snow on haul roads in a manner that will protect roads and adjacent resources. Remove or place snow berms to prevent water concentration on the roadway or on erodible side-slopes or soils.	Coarse and Fine Sediment: Road erosion with potential transport to the channel and floodplain.	Turbidity OAR 340-041-0036
R 75	Wash equipment at sites with no potential for runoff into waterbodies, floodplains, or wetlands.	Coarse and Fine Sediment: Soil erosion with potential transport to the channel and floodplain.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 76	Use water or approved surface stabilizers/dust palliatives to reduce surfacing material loss and buildup of fine sediment that may wash off into waterbodies, floodplains, or wetlands.	Coarse and Fine Sediment: Road surfacing becoming detached and blowing or washing from roadways to ditchlines to stream channels.	Turbidity OAR 340-041-0036
		Maintenance	
R 77	Avoid routine machine cleaning of ditches during the wet season, generally, November through May.	Coarse and Fine Sediment: Removing vegetation or fill material from ditches in the wet season would increase bare soils susceptible to erosion, with potential delivery to stream channels.	Turbidity OAR 340-041-0036
R 78	Avoid undercutting of cut-slopes when cleaning ditchlines. Seed and mulch bare soils including cleaned ditchlines that are hydrologically connected to stream channels.	Coarse and Fine Sediment: Removing vegetation or fill material from ditches or undercutting backslopes would increase bare soils susceptible to erosion, with potential delivery to stream channels.	Turbidity OAR 340-041-0036
R 79	Remove slide material when it is obstructing road surface and ditchline drainage.	Coarse and Fine Sediment: Slide material, being eroded by ditch streamflow and routing to stream channels, especially during storms.	Turbidity OAR 340-041-0036
R 80	End-haul sloughed or excavated materials to a stable site outside Riparian Management Areas with no potential to reach waterbodies, wetlands and floodplains. Avoid wasting loose ditch or surface material over the shoulder where it can cause stream sedimentation or weaken slump prone areas.	Coarse and Fine Sediment: Wasting soil material on steep slopes, may trigger a debris avalanche that could enter a stream channel, delivering sediment and debris.	Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Turbidity OAR 340-041-0036
R 81	Keep road inlet and outlet ditches, catch basins, and culverts free of obstructions, particularly before and during winter precipitation and spring run-off.	Coarse and Fine Sediment: Plugged culverts by sediment and debris, leading to loss of road fill and movement of road sediment downstream.	Turbidity OAR 340-041-0036
R 82	Repair damaged inlets and downspouts to maintain drainage design capacity.	Coarse and Fine Sediment: Culverts plugged by sediment and debris, leading to los of road fill and movement of road sediment downstream.	Turbidity OAR 340-041-0036
R 83	Avoid blading and shaping of road surfaces during the wet season, generally November through May).	Coarse and Fine Sediment: Loose aggregate and fines susceptible to erosion, with potential delivery to stream channels.	Turbidity OAR 340-041-0036
R 84	Blade and shape roads to conserve existing aggregate surface material, retain the original crowned or out-sloped self-draining cross section, prevent or remove eroding berms except those designed for slope protection, and other irregularities that retard normal surface runoff.	Coarse and Fine Sediment: Road erosion with potential transport to the channel and floodplain.	Turbidity OAR 340-041-0036
R 85	Eliminate undesirable berms that retard surface runoff.	Coarse and Fine Sediment: Road erosion with potential transport to the channel and floodplain.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 86	Retain low-growing, herbaceous ground cover and brush on cut-and-fill slopes. Where workable, retain ground cover in ditchlines, except where sediment deposition or obstructions require maintenance.	Coarse and Fine Sediment: Increased vegetative cover rapidly diminishes surface erosion potential, and delivery of sediment to stream channels.	Turbidity OAR 340-041-0036
	Road Stormproofing		
R 87	Stormproof open or older roads with continued use, but infrequent maintenance. Stormproof new temporary roads, if over-winter. Stormproofing may involve: • Relieving inboard ditches more frequently. • Rocking road surfaces. • Seeding, mulching and re-vegetating erosion prone surfaces, where sediment delivery to stream channels may result. • Using erosion control/ vegetative treatments under road decommissioning section. • Applying site-specific measures to alleviate concentration of road drainage causing erosion and sediment delivery to streams. Measures include: - Lowering risk of stream diversion potential at stream crossings - Upgrading stream crossing to pass the 100 year flood with allowance for debris and bedload - Removing or lowering unstable fills - Outsloping insloped ditch roads - Road drainage control to stable dissipation areas.	Coarse and Fine Sediment: Chronic surface erosion with delivery to waterbodies, floodplains and wetlands. Lower the risk of future large storm-related erosion, failures and sedimentation.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 88	Suspend stormproofing work if rain saturates soils to the extent that there is potential for movement of sediment from the road to the stream.	Coarse and Fine Sediment: Surface erosion with delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
	Road Closure and Decommissioning		
R 89	Decommission new roads not included in the permanent road system upon completion of use Decommission older, under used roads that require high maintenance. Road decommissioning may include any combination of the following measures:		
R 90	**Closure:** Close roads not needed, but not recommended to be fully decommissioned. When this measure is used by itself, it applies only to roads that do not significantly reroute hillslope drainage, involve stream channels, or present slope stability hazards. Close roads using methods such as gates, guard rails, earth/log barricades, etc. to reduce or eliminate erosion and sedimentation due to traffic on roads.	Coarse and Fine Sediment: Wheel track formation and rilling/gullying with delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 91	Place woody material or other appropriate barriers to discourage off-highway vehicle use on decommissioned roads, unless specifically designated for this use.	Coarse and Fine Sediment: Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 92	Restore natural stream crossings and maintenance free drainage: Convert existing drainage structures such as ditches and cross drain culverts to a long-term no maintenance drainage configuration such as large dips, outsloped road surface, and well drained, high-capacity waterbars.	Coarse and Fine Sediment: Sediment accumulation or debris plugging cross drains causing road erosion.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 93	Remove stream crossing culverts and entire in-channel fill material during low flow (generally, June 15 to September 15) prior to fall rains.	Coarse and Fine Sediment: Sediment accumulation or debris plugging stream culverts, causing road gully erosion or stream crossing failure. Stream channels readjusting to active channel width, entraining road fill materials.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 94	Place excavated material from removed stream crossings n a stable location where it would not reenter the stream. If necessary, place sediment and erosion controls around all stockpiled material.	Coarse and Fine Sediment: Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 95	Reestablish stream crossings to the natural stream gradient. Excavate sideslopes back to a straight or slightly concave profile, generally less than 50% gradient. Reestablish floodplains at bankfull height.	Coarse and Fine Sediment: Streambed nickpoints traveling upstream, scouring below the armor layer in gravel bed streams causing excessive channel erosion. Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 96	Construct oversized waterbars or cross ditches that will remain functional on each side of stream crossings.	Coarse and Fine Sediment: Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 97	**Erosion control and vegetative treatments:** Apply erosion control, such as seeding and mulching, to all hydrologically connected road related bare soil surfaces, where erosion could occur, including streambanks and stream-adjacent side slopes following culvert removal. Place sediment trapping materials such as straw bales and jute netting at the toe of stream-adjacent side slopes following culvert removal. Complete seeding and mulching erosion control work by October 15 of each year. When straw mulch or rice straw mulch is used; require certified weed free, if readily available. Mulch shall be applied at no less than 2000 lbs/acre. Vegetative cuttings, shrubs and trees may be considered as needed for erosion control. Planting of shrubs and trees should occur during the winter dormant season.	Coarse and Fine Sediment: Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 98	**Decompaction:** Implement decompaction measures, including ripping or subsoiling to an effective depth; generally to 24-36 inches. Treat compacted areas including the roadbed, landings, construction areas, and spoils sites.	Coarse and Fine Sediment: Water concentration eroding compacted surfaces resulting to sediment delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 99	**Pull back/Obliteration** Pull back unstable road fill and either end-haul or recontour to the natural slopes.	Coarse and Fine Sediment: Mass wasting resulting in sediment delivery to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 100	Suspend decommissioning activities if rain saturates soils to the extent that there is potential for movement of sediment from the road to the stream.	Coarse and Fine Sediment: Surface erosion delivering to waterbodies, floodplains and wetlands.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
Water Source Development and Use			
R 101	Construct water sources during the lowest flows (generally, August through October).	Coarse and Fine Sediment, and Aquatic Habitat: Changing or removing stream habitat and associated stream turbidity.	Biocriteria OAR 340-041-0011 Turbidity OAR 340-041-0036
R 102	Locate road approaches to in-stream water source developments so as to limit disturbance to vegetation and modification of streambanks. Surface these approaches with rock.	Coarse and Fine Sediment, and Toxins: Road surfacing, washing into the stream during storms.	Turbidity OAR 340-041-0036
R 103	Avoid use of road fills for water impoundment dams unless specifically designed for that purpose. Existing road fill impoundments are required to pass 100-year flood events without failure. Upgrade existing impoundments when economical to do so.	Coarse and Fine Sediment, and Toxins: Road fill washout, leading to stream sedimentation	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Road Building Waste Materials OAR 340-041-0007 Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
R 104	Direct pass through flow and/or overflow from in-channel and off-channel water developments back into the stream .	Low Flows: Decreasing low flows, potentially causing increased stream water temperatures, and decreased stream oxygen levels.	Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028
R 105	Overflow from water harvesting ponds should be directed to a safe non-eroding dissipation area, and not into a stream channel.	Augmenting Streamflow: Detained water, potentially causing increased stream water temperatures, and decreased stream oxygen levels.	Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
R 106	Limit the construction of temporary pump chances. When intermittently pumping , use a temporary liner to create and remove these water drafting sites.. Avoid interfering with fish passage or adverse effects on aquatic life.	Low Flows: Decreasing low flows, potentially causing increased stream water temperatures, and decreased stream oxygen levels.	Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028
R 107	Do not place pump intakes on the substrate or edges of the stream channel.	Coarse and Fine Sediment, and Stream Habitat: Changing or removing stream habitat and associated stream turbidity.	Biocriteria OAR 340-041-0011 Turbidity OAR 340-041-0036

Timber Harvest Activities

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-18. Best Management Practices For Timber Harvest Activities

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
		Cable Yarding	
TH 1	Remove slash introduced into waterbodies that may be floatable e.g. limbs, tops,before the next precipitation and runoff event.	Coarse and Fine Sediment: Debris jams can form damming the stream and directing streamflow against banks, leading to bank erosion or a dam break flood.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and(13) Turbidity OAR 340-041-0036
TH 2	Design yarding corridors so as to limit canopy loss in riparian management areas and to meet shade targets. Techniques include limiting the number of such corridors, using narrow widths, and using a perpendicular orientation to the stream.	Water Temperature: Yarding corridors in RMA's can result in vegetation canopy loss due to removal for safety and yarding operations. Decreases in canopy can result in losses of effective shade and exposure of stream channel to solar radiation, resulting in heating of the waterbody.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and(13) Temperature OAR 340-041-0028
TH 3	Where workable, require full suspension over flowing streams, non-flowing streams with erodible bed and bank, and jurisdictional wetlands.	Coarse and Fine Sediment: Log yarding through waterbodies can cause direct introduction of sediment into water or channels resulting in accumulation of sediment and turbidity. Displacement of stream and wetland bed and banks exposing soil to erosion resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Turbidity OAR 340-041-0036
TH 4	Limit downhill logging into riparian management areas where yarding trails can converge, and potentially intersect the stream network.	Coarse and Fine Sediment: Downhill logging into RMA's could result in converging skid paths intersecting stream channels, With less than full suspension, which could result in sediment accumulation, delivery and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and(13) Turbidity OAR 340-041-0036
TH 5	Where slopes exceed 60 percent along stream channels, yard with full suspension, or one-end suspension using seasonal restrictions. Yard remaining areas using one-end suspension.	Coarse and Fine Sediment: Slopes greater than 60% present a high risk of soil displacement and transport downslope to RMAs due to gravitational forces. Increased displacement from lack of log suspension can cause excessive displacement, exposure of sediment sources and delivery to waterbodies and wetlands.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and(13) Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
TH 6	Implement erosion control measures such as waterbars, slash placement and seeding in cable yarding corridors where the potential for erosion and delivery to waterbodies, floodplains and wetlands exists.	Coarse and Fine Sediment: Exposure of soils to erosive forces of water with potential delivery to waterbodies and wetlands.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and(13) Turbidity OAR 340-041-0036
Ground-Based Harvesting			
TH 7	Exclude equipment from riparian management area retention areas (60 from the edge of the active stream channel for fishbearing and perennial streams, lakes and ponds, and 35 feet for intermittent streams), except for road crossings, restoration, wildfire, or similar operational reasons.	Coarse and Fine Sediment: Displacement and exposure of soils through equipment operation with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity Temperature: Loss of vegetation canopy due to removal during yarding operations. Decreased shade and exposure of stream channel to solar radiation and increased heating.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Temperature OAR 340-041-002 Turbidity OAR 340-041-0036
TH 8	Exclude ground-based equipment on hydric soils.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 9	Plan use on existing and new skid trails, to be less than 12 percent of the harvest area.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 10	Limit width of skid roads to what is operationally necessary for the equipment.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 11	Ensure one-end suspension of logs; e.g. integral arch on all conventional ground-base yarding equipment.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 12	Restrict ground-based harvest and skidding operations to periods of low soil moisture when soils have resistance to compaction and displacement.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
TH 13	As a first priority, use ground-based equipment on existing compacted surfaces.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 14	Limit conventional ground-based equipment to slopes less than 35 percent.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 15	When specialized ground-based mechanized equipment is used on slopes greater than 35%, monitor use, and restrict where water and sediment could channel overland.	Coarse and Fine Sediment: Compaction, displacement, and exposure of soils through equipment operation with potential for increased runoff and delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 16	Designate skid trails where water from trail surface would not be channeled into unstable areas adjacent to waterbodies, floodplains, and wetlands.	Coarse and Fine Sediment: Compaction of skid trails resulting in additional surface flow to unstable areas. Increases in water to unstable areas can elevate pore pressure and weight of unstable area causing mass wasting and delivery of sediment and turbidity to waterbodies and wetlands.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 17	When hand falling, directionally fall trees towards skid trails. When mechanically harvesting, directionally fall and bunch trees to facilitate skidding.	Coarse and Fine Sediment: Minimize compaction of skid trails resulting in loss of infiltration, surface water flow and erosion of exposed soils. Potential delivery to waterbodies and wetlands resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 18	Apply erosion control practices to skid roads and other disturbed areas with potential for erosion and subsequent sediment delivery to waterbodies, floodplains, or wetlands. These practices could include seeding, mulching, water barring, tillage, and woody debris placement. Use guidelines from the road decommissioning section.	Coarse and Fine Sediment: Exposure of soils to erosive forces of water with potential delivery to waterbodies and wetlands.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 19	Construct waterbars on skid trails using guidelines in Table I-21.	Coarse and Fine Sediment: Exposure of soils to erosive forces of water with potential delivery to waterbodies and wetlands.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
TH 20	Allow logging on snow when snow depth is greater than 18 inches or over frozen ground.	Coarse and Fine Sediment: Displacement, compaction, and exposure of soils through equipment operation with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1)&(13) Turbidity OAR 340-041-0036
TH 21	Block skid roads that intersect haul roads at the end of seasonal use.	Coarse and Fine Sediment: Displacement, compaction, and exposure of soils through equipment operation with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1)&(13) Turbidity OAR 340-041-0036
TH 22	Where feasible in dry forest types, plan one entry operations, by combining ground-based timber harvesting with pre-commercial thinning, and/or biomass opportunities, or reducing fuel loading.	Coarse and Fine Sediment: Displacement, compaction, and exposure of soils through multiple-entry equipment operations with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007 (1)&(13) Turbidity OAR 340-041-0036
Helicopter			
TH 23	Consider the use of helicopter or aerial logging systems for unavoidable water quality impacts from road construction or ground-based timber yarding, where other BMPs would be more costly or have limited effectiveness.	Coarse and Fine Sediment: Soil exposure due to road construction or yarding operations resulting in soil erosion with potential transport to the waterbody resulting in sedimentation and turbidity. Temperature: Loss of vegetation canopy due to removal during yarding operations. Decreased shade and exposure of stream channel to solar radiation and increased heating.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
Horse			
TH 24	Within riparian management areas, limit horse logging to slopes less than 20 percent.	Coarse and Fine Sediment: Soil on skid trails exposed to water erosion with potential delivery to waterbodies, floodplains, and wetlands resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036
TH 25	Construct waterbars on horse skid trails when there is potential for soil erosion and delivery to waterbodies, floodplains, and wetlands.	Coarse and Fine Sediment: Soil on skid trails exposed to water erosion with potential delivery to waterbodies , floodplains, and wetlands resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Turbidity OAR 340-041-0036

Silvicultural Activities

See *Summary of Oregon Water Quality Standards* additional details about the standards and regulations that are associated with the best management practices.

Table I-19. Best Management Practices For Planting, Pre-Commercial Thinning, Fertilization, And Stand Conversion

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
		Planting	
S 1	Limit the crossing of stream channels with motorized support vehicles (e.g., ATV's) and mechanized equipment to existing road crossings.	Coarse and Fine Sediment: Vehicle and equipment crossing streams can cause breakdown of bed and banks exposing soil to water erosion and resulting turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
		Pre-Commercial Thinning	
S 2	Limit the crossing of stream channels with motorized support vehicles (e.g., ATV's) and mechanized equipment to existing road crossings.	Coarse and Fine Sediment: Vehicle and equipment crossing streams can cause breakdown of bed and banks exposing soil to water erosion and resulting turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
S 3	Fell thinned trees away from stream channels when possible.	Coarse and Fine Sediment: Accumulation of slash in channels can redirect flows out of the stream channel, increasing stress on banks and resulting in streambank and floodplain erosion and increases in local turbidity	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
S 4	Scatter treatment debris on disturbed soils and water bar any yarding trails that could erode and deposit sediment in water bodies, floodplains, and wetlands	Coarse and Fine Sediment: Erosion of exposed soil and delivery to waterbodies and wetlands resulting in turbidity increases.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
		Fertilization	
S 5	For streams and waterbodies that support domestic use, apply fertilizer further than 100 feet from the edge of the active channel or shoreline.	Nitrate leaching to surface and groundwater affecting domestic water use.	10 mg/L nitrate nitrogen for domestic water supply EPA 440/5-86-001
S 6	Locate storage, transfer, and loading sites outside riparian management areas and separated from hydrological connections: eg road ditches that are linked to stream channels.	Nutrient Enrichment: Spilling of fertilizer with potential delivery of nutrients to waterbodies and wetlands through leaching or direct surface water transport.	0.5 mg/L toxic to rainbow trout Biocriteria OAR 340-041-0011
S 7	When aerially applying fertilizer, avoid drift of fertilizer into waterbodies	Nutrient Enrichment: Application of Nitrate to potentially nitrogen rich riparian areas, leading to leaching and delivery of nitrates through local groundwater to and water bodies.	0.5 mg/L toxic to rainbow trout Biocriteria OAR 340-041-0011

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
S 8	When aerially applying fertilizer, suspend fertilizer application when heavy precipitation is expected at the time of application.	Nutrient Enrichment: Application of Nitrate to potentially nitrogen rich riparian areas, leading to leaching and delivery of nitrates through local groundwater to and water bodies.	0.5 mg/L toxic to rainbow trout Biocriteria OAR 340-041-0011
Stand Conversion Restoration			
S 9	Within riparian management areas, design size, shape and placement of restoration areas, to maintain as much effective shade as possible.	Water Temperature: Decreases in canopy can result in losses of effective shade and exposure of stream channel to solar radiation, resulting in heating of the waterbody.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Temperature OAR 340-041-0028
S 10	Within riparian management areas, limit mechanical ground-based equipment to slopes less than 35% and beyond 35 feet from the edge of the active stream channel.	Coarse and Fine Sediment: Displacement and exposure of soils through equipment operation with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Temperature OAR 340-041-0028

Fire and Fuels Management

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-20. Best Management Practices For Fire And Fuels Management

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
	Underburn, Concentration Burn, and Broadcast Burn		
F 1	Allow low intensity underburns to back into riparian management areas; however no ignition would occur within riparian management areas, unless prescribed for restoration purposes. Keep broadcast burns and concentration burns out of riparian management areas, unless prescribed for restoration purposes, e.g. sudden oak death sanitation. Locate ignition lines above large open meadows associated with stream channels, unless prescribed for restoration.	Coarse and Fine Sediment, and Temperature: Bare soil in RMA is subject to surface erosion and potential sediment delivery to adjacent waterbody. Loss of riparian vegetation due to wildfire could reduce shade and increase water temperature.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
F 2	Avoid underburning In dry forest types, where fuel loads are elevated, by encouraging whole tree yarding.	Coarse and Fine Sediment: Underburning in dry forest types with heavy fuel loading could result in soil exposure and tree mortality resulting in soil erosion with potential transport to the waterbody resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007 (1) and (13) Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
F 3	Avoid ignition of large woody material that is touching the high water mark of a waterbody or that may be affected by high flows.	Coarse and Fine Sediment: Large wood provides channel stabilization and energy dissipation, thus reducing channel erosion and subsequent sedimentation.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F 4	Avoid delivery of foam or additives to waterbodies, floodplains, or wetlands. Store and dispose of ignition devices/ materials (e.g., flares, plastic spheres, etc.) outside riparian management areas or a minimum of 100 feet from waterbodies, floodplains, and wetlands. Maintain and refuel equipment (e.g., drip torches, chainsaws, and) a minimum of 100 feet from waterbodies, floodplains, and wetlands. Portable pumps can be refueled on-site within a spill containment system.	Chemicals: Direct contamination of waterbodies.	Toxic Substances OAR 340-041-0033

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
F 5	Limit firelines inside riparian management areas. Construct firelines by hand on all slopes greater than 35 percent. Use erosion control techniques such as tilling, waterbaring, or debris placement on firelines. Construct waterbars on tractor and hand firelines. Avoid placement of any fireline where water would be directed into waterbodies, floodplains, wetlands, headwalls, or areas of instability.	Coarse and Fine Sediment: Firelines can channel water and sediment into waterbodies.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Pile and Burn			
F 6	Avoid mechanical piling in areas that could deliver sediment to waterbodies, floodplains, wetlands.	Coarse and Fine Sediment: Ground disturbance reduces infiltration and increases surface runoff with subsequent soil movement. Erosion more likely on steeper slopes.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Mechanical and Manual Fuel Treatments			
F 7	No mechanical fuel reduction equipment within 60' of streams, unless prescribed for restoration. Limit mechanical fuel reduction equipment to slopes less than 35 percent. Restrict non-track mechanized equipment to slopes less than 20 percent.	Coarse and Fine Sediment: Ground-based equipment reduces infiltration and increases surface runoff with subsequent soil movement.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F 8	Use temporary stream crossings if necessary to access the opposite side with any equipment or vehicles (including ATVs). Follow Temporary Stream Crossing practices under Roads section.	Coarse and Fine Sediment: Stream crossings subject to streambank damage and erosion.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F 9	Place residual slash on disturbed areas.	Coarse and Fine Sediment: Bare soil areas are subject to erosion and subsequent sediment delivery to waterbody.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F 10	Maintain and refuel equipment (e.g., drip torches, chainsaws, and a minimum of 100 feet from waterbodies, floodplains, and wetlands. Portable pumps can be refueled on-site within a spill containment system.	Petroleum Products: Direct contamination of waterbodies.	Toxic Substances OAR 340-041-0033

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
	Wildfire Suppression		
F 11	Limit firelines inside riparian management areas. Where hand constructed firelines are necessary in riparian management areas, angle the approach, where feasible, rather than have it perpendicular to the riparian management area. Limit use of heavy equipment on slopes greater than 35 percent.	Coarse and Fine Sediment: Ground-based equipment reduces infiltration and increases surface runoff with subsequent soil movement. Soil disturbance causes soil erosion and potential for soil movement to waterbody.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F 12	Prevent cutting of logs or woody material if any portion of that material extends into the stream channel, unless for restoration. Fall snags in the riparian management area towards the stream channel when felling is necessary for safety or fire suppression activities.	Coarse and Fine Sediment: Stream bank or channel erosion, caused by destabilizing banks and affecting water flow against debris, diminishing stream complexity with possible effects on aquatic life.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
F13	Avoid locating incident bases, camps helibases, staging areas, constructed helispots, and other centers for incident activities in riparian management areas or within 200 feet of any waterbody, floodplain, or wetland.	Coarse and Fine Sediment, , Temperature, and Petroleum Products: Riparian disturbance from equipment and people could increase sediment. Removal of riparian vegetation could cause water temperature increases. Accidental spillage of fuel and other chemicals could enter waterways.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) Temperature OAR 340-041-0028 Toxic Substances OAR 340-041-0033 Turbidity OAR 340-041-0036
F 14	Locate and maintain portable sanitation facilities at incident bases, camps (including spike/ remote camps), helibases, staging areas, constructed helispots, and other centers for incident activities in accordance with state and local regulations.	Bacteria: Contamination from human waste.	Bacteria OAR 340-041-0009
F 15	Keep chemical retardant, foam, or additives out of waterbodies, floodplains, or wetlands. Avoid use of chemical retardants within the riparian management area. Apply aerial retardant adjacent to riparian management areas by making parallel passes.	Chemical Retardants: Contamination of waterbodies from chemical retardant.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) Toxic Substances OAR 340-041-0033

<table>
<tr><th>BMP Number</th><th>Best Management Practices</th><th>Input Variables and Causal Mechanisms</th><th>Water Quality Standards and Regulations</th></tr>
<tr><td colspan="4">Rehabilitation</td></tr>
<tr><td>F 16</td><td>Implement emergency fire rehabilitation treatments to accomplish erosion control as quickly as possible and before the wet season.

Soil and water conservation practices may include:

Native or other ecologically appropriate vegetation for short-term cover development and long-term recovery, unless not available in quantities necessary for the emergency response.

Mulch with straw, wood chips ,or other suitable material. To avoid contamination when mulching, use certified weed-free straw mulch or rice straw where available.

Straw wattles.

Log erosion barriers.

Spreading slash on bare soils.

Placing channel stabilization structures.

Placing sediment retention structures in channel.

Placing trash racks above road drainage structures.

Installing drainage structures, such as water bars or drainage dips, on firelines, fire roads, and other cleared areas according to guidelines in Table 5 (Waterbar spacing by gradient and erosion class).

Repairing damaged road drainage facilities.

Blocking or decommission roads and trails.</td><td>Coarse and Fine Sediment:
Bare soil areas are subject to erosion and subsequent sediment delivery to streams and waterbodies. Sediment transfer hazard within channels, if sediment appreciably moves off-site to important downstream waters.</td><td>Antidegradation
OAR 340-041-0004(1)
Biocriteria
OAR 340-041-0011
Statewide Narrative OAR 340-041-0007(1) and (13)
Turbidity
OAR 340-041-0036</td></tr>
</table>

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
	Post-Fire Road Improvement		
F 17	Implement emergency fire rehabilitation treatments to accomplish erosion control as quickly as possible and before the wet season. Soil and water conservation practices may include: Reduce road system hydrologic conductivity. Increase peak flow capacity of stream crossing culverts to accommodate the 100-year design flood. Prevent culvert plugging. Correct stream diversions. Excavate potential fillslope failures.	Coarse and Fine Sediment: Erosion and runoff from bare soil areas onto roads and increased truck traffic from salvage logging causing sediment delivery to streams and waterbodies. Sediment and debris reducing stream crossing drainage structures capacity, increasing risk for failure with flooding.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
	Fuel/Retardant Transport		
F 18	If more than 42 gallons of fuel or combined quantity of petroleum product and chemical substances, as project materials, would be transported to a project site, the following precautions would be implemented. 1. Plan a safe route and transfer sites that could contain the transported volume. 2. Plan an active dispatch system that can relay the information to appropriate resources. 3. Ensure a spill containment kit that can adsorb and contain 55 gallons of petroleum product and chemical substances is readily available. 4. Provide for immediate notification in the event of a spill. Have a radio equipped vehicle lead the chemical or fuel truck to the project site. 5. Assemble a spill notification list that includes the district hazardous materials coordinator, DEQ, and spill clean-up contractors. 6. Construct a water user contact list with address and phone numbers. 7. When operating within Source Water Watersheds, pre-estimate travel times through the watershed to predict downstream arrival times. 8. Be prepared to sample water and carry sample containers.	Petroleum and Chemical Substances: Spillage into waterbodies with chemical contamination of waterbodies.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Toxic Substances OAR 340-041-0033

Table I-21. Waterbar Spacing By Gradient And Erosion Class

Gradient	Waterbar Spacing (feet)[1] Per Erosion Class[2]		
	High Class	Moderate Class	Low Class
2 to 5%	200 ft.	300 ft.	400 ft.
6 to 10%	150 ft.	200 ft.	300 ft.
11 to 15%	100 ft.	150 ft.	200 ft.
16 to 20%	75 ft.	100 ft.	150 ft.
21 to 35%	50 ft.	75 ft.	100 ft.
36+%	50 ft.	50 ft.	50 ft.

[1]Spacing is determined by slope distance and is the maximum allowed for the grade.
[2]The erosion classes include the following rock types:
High: granite, sandstone, andesite porphyry, glacial or alluvial deposits, soft matrix conglomerate, volcanic ash, and pyroclastics
Moderate: basalt, andesite, quartzite, hard matrix conglomerate, and rhyolite
Low: metasediments, metavolcanics, and hard shale

Surface Source Water for Drinking Water

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-22. Best Management Practices For Surface Source Water For Drinking Water

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
SW 1	Sanitary facilities would be planned, located, designed, constructed, operated, inspected, and maintained to minimize possibilities of water contamination.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13)
SW 2	Locate contractor camps outside Oregon Department of Environmental Quality sensitive zones in surface source water watersheds. If this is not possible, require self-contained sanitary facilities.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13)
SW 3	Require self-contained sanitary facilities in surface source water watersheds, when long-term camping (greater than 14 days) is involved with contract implementation.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13)
SW 4	Provide self-contained sanitary facilities when there is high recreational use (almost continuous occupancy) within Oregon Department of Environmental Quality sensitive zones or along streams above domestic water diversions of record.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13)
SW 5	Locate pack, riding, restoration, and logging stock facilities 200 feet away from watercourses upstream of source drinking diversions.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13)
SW 6	Do not allow surface occupancy within 200 feet of a recorded domestic or public drinking water diversion.	Bacteria: Fecal Coliform enrichment of local groundwater and surface water with delivery to downstream drinking water diversion.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13) Toxic Substances OAR 340-041-0033

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
SW 7	Do not apply sewage sludge as a soil amendment in surface source water watersheds, above Domestic Water diversions of record, or within riparian management areas.	Toxic Pollutants: Leaching and surface water movement can transport toxics and bacteria downstream to water supply diversions. Some domestic supplies have no ability to detect or treat this pollution.	Antidegradation OAR 340-041-0004(1) Bacteria OAR 340-041-0009 Statewide Narrative OAR 340-041-0007(1) and (13) Toxic Substances OAR 340-041-0033
SW 8	Avoid loading, or storing chemical, fuel, or fertilizer in sensitive zones in surface source water watersheds.	Toxic Pollutants, Oil, Gas, and Nutrients: Leaks, spills, and improper handling of pesticides, herbicides and petroleum products can leach or be transported by surface water to drinking water diversion points.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Toxic Substances OAR 340-041-0033
SW 9	Conduct equipment maintenance outside site- specific sensitive zones in surface source water watersheds.	Toxic Pollutants, Oil, and Gas: Leaks, spills, and improper handling petroleum products can leach or be transported by surface water to drinking water diversion points.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Toxic Substances OAR 340-041-0033
SW 10	Use non-oil-based dust suppressants in surface source water watersheds.	Toxic Pollutants, Oil, and Gas: Leaks, spills, and improper application of oil based dust control products can introduce petroleum products to surface water and to drinking water diversion points.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Toxic Substances OAR 340-041-0033
SW 11	Avoid mineral lease surface occupancy within sensitive zones in surface source water watersheds.	Toxic Pollutants, Oil, and Gas: Leachate from mineral operations or equipment use may contain chemicals and wastes that are transported and delivered to drinking water diversion points.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Toxic Substances OAR 340-041-0033
SW 12	Use fire retardant and surfactants as a last resort in fire suppression activities in surface source water watersheds.	Toxic Pollutants: Direct application of fire retardant and surfactants to waterbodies above drinking water intakes can cause delivery of Nitrate reaching concentrations as high as 33 mg/L, well above the primary water quality standard of 1 mg/L. The main chemical of concern in streams 24 hours after a retardant drop is un-ionized ammonia (NH_3) is the principal toxic component to aquatic species.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and(13) Toxic Substances OAR 340-041-0033

Recreation

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-23. Best Management Practices For Recreation

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
All Recreation Facilities			
REC 1	Implement erosion control measures on all recreation sites to stabilize exposed soils.	Coarse and Fine Sediment: Minimize sediment delivery to wetlands, floodplains, and waterbodies.	Turbidity OAR 340-041-0036
REC 2	Locate new recreational facilities, developed and dispersed sites, outside of the water influence area. Low impact uses, such as hiking trails, picnic sites, or water dependant facilities (e.g., boat ramps or docks), are excluded.	Coarse and Fine Sediment: Minimize sediment delivery resulting from surface erosion.	Bacteria OAR 340-041-0009 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
Developed Recreation Sites			
REC 3	Sealed vault toilets will be used at all developed recreational facilities, unless a sewage system and drainfield is approved by the Department of Environmental Quality.	Bacteria: Bacterial pollution from improperly constructed sanitation facilities could be injurious to the health of humans and aquatic organisms.	Bacteria OAR 340-041-0009
REC 4	Construct and maintain refuse disposal sites to avoid water contamination.	Bacteria: Bacteria could enter surface and groundwater if garbage is not disposed of properly.	Bacteria OAR 340-041-0009
REC 5	When conducting recreation site maintenance, do not cut logs or coarse woody debris if any portion of that material extends in the active stream channel.	Coarse and Fine Sediment: Sediment storage, streambank stability, and reduction of turbidity.	Antidegradation OAR 340-041-004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Water Dependent Facilities			
REC 6	Construct boat ramps and approaches with hardened surfaces.	Coarse and Fine Sediment: Impacts to streambanks, turbidity	Turbidity OAR 340-041-0036
Off-Highway Vehicle (OHV) Trails			
REC 7	Use existing hardened stream crossings to the extent possible when constructing trails through Riparian Management Areas.	Coarse and Fine Sediment, Bacteria and Pathogens, Oil, and Toxins: OHVs accessing streams at multiple points, breaking down banks, disturbing stream substrate, causing turbidity and stream sedimentation. Driving through water column with possible contamination of waters with oils and toxics, bacteria and noxious weeds, washed from OHV or tires.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Statewide Narrative Criteria Toxics OAR 340-041-0007 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
REC 8	When constructing or maintaining trails within Riparian Management Areas, do not cut logs or coarse woody debris if any portion of that material extends into the active stream channel.	Coarse and Fine Sediment: Stream bank or channel erosion, caused by destabilizing banks and affecting water flow against debris, diminishing stream complexity with possible effects on aquatic life.	Antidegradation OAR 340-041-004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
REC 9	Avoid vehicle and off-highway vehicle use in streams, ponds, wetlands, and other waters.	Coarse and Fine Sediment, and Toxic Pollutants: Direct delivery of sediment and/or petroleum based fluids from vehicles is unnecessary degradation of waters of the State.	Toxic substances OAR 430-041-0033 Turbidity OAR 340-041-0036
REC 10	Stream crossings would be designed to accommodate active channel width, bed load, and fish passage without exceeding capacity or diversion for the 100-year flood event.	Coarse and Fine Sediment: Floodwaters exceeding crossing capacity, causing overtopping of fills, with ensuing headcutting and loss of trail fill.	Statewide Narrative Criteria Sediment, Adverse Deposits OAR 340-041-0007 Turbidity OAR 340-041-0036
REC 11	Suspend construction or maintenance of trails, where erosion and runoff into waterbodies would occur.	Coarse and Fine Sediment: Sediment from trail related run-off causing stream turbidity.	Turbidity OAR 340-041-0036
REC 12	Locate staging areas outside riparian management areas. Design or upgrade staging areas to prevent sediment/pollutant delivery to wetlands, floodplains, and waterbodies (e.g., rocking or hardening)	Coarse and Fine Sediment, and Toxic Pollutants: Sediment or petroleum products reaching streams with effects on aquatic life.	Biocriteria OAR 340-041-0011 Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Statewide Narrative Criteria Toxics OAR 340-041-0007 Turbidity OAR 340-041-0036
REC 13	Harden trail approaches to stream crossings using materials such as geotextile fabric and crushed rock aggregate.	Coarse and Fine Sediment: Sediment reaching waterbodies from trail run-off.	Turbidity OAR 340-041-0036
REC 14	Drain dips will be installed on approaches to stream crossings and reinforced with rock for longevity..	Coarse and Fine Sediment: Sediment from trail related run-off, run-off from trail surfaces with delivery to waterbodies, floodplains, and wetlands resulting in turbidity and sedimentation.	Turbidity OAR 340-041-0036
REC 15	Do not use chemically treated wood that would cause water quality degredation in construction of bridges over streams, where materials are in contact with the stream or may leach into the soil or water.	Toxic Pollutants: Leaching of harmful chemicals from treated wood into waterbodies, floodplains and wetlands.	Toxic substances OAR 430-041-0033
REC 16	During construction, perennial stream crossings may require a temporary flow diversion structure through the work area. (See Roads Section for Stream Crossing BMPs.)	Coarse and Fine Sediment: Exposed soils may be vulnerable to erosion and sediment deposition into streams.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
REC 17	Prevent vehicle access to nearby wetlands by using suitable barriers.	Coarse and Fine Sediment: Defining trail route may prevent development of new trails into fragile areas susceptible to compaction and sediment transport to water resources.	Turbidity OAR 340-041-0036
REC 18	Where trails intersect road ditches, provide hardened crossings. Divert water from the trail to keep from reaching wetlands, floodplains, and waterbodies.	Coarse and Fine Sediment Exposed soils may be vulnerable to erosion, resulting in deposition to road ditches that could flow into nearby streams.	Turbidity OAR 340-041-0036
REC 19	If trail width is too wide for the designated use (such as old roads converted to trails) consider tilling one side of the trail, covering with brush, and seeding or planting.	Coarse and Fine Sediment: Wider trails are more prone to erosion and sediment delivery to waterbodies.	Turbidity OAR 340-041-0036
REC 20	Repair rills and gullies using appropriately sized equipment or by hand.	Coarse and Fine Sediment: Unless tread erosion is maintained regularly, erosion escalates and can route sediment to waterbodies	Turbidity OAR 340-041-0036
REC 21	Waterbars, drain dips, and lead off ditches will be constructed or repaired as needed. These features may need rock reinforcement to promote longevity. Drain dips or lead-off features are the preferred design.	Coarse and Fine Sediment: Drainage features can erode and gully and route run-off into streams resulting in sediment delivery to waterbodies, floodplains and wetlands.	Turbidity OAR 340-041-0036
REC 22	Drain dips or lead off ditches will be constructed on steeper gradient trails and approaches to stream crossings.	Coarse and Fine Sediment: Water volume concentration can occur, where there are insufficient drain dips or lead off ditches, with erosion and gullying, resulting in sediment delivery to waterbodies, floodplains and wetlands.	Turbidity OAR 340-041-0036
		Trails (Hiking)	
REC 23	When constructing or maintaining trails within riparian management areas, do not cut logs or coarse woody debris if any portion of that material extends into the active stream channel. Use alternative passage options, such as earthen ramps, small notch steps, or slight trail realignments, to facilitate maintenance of intact logs.	Coarse and Fine Sediment: Stream bank or channel erosion, caused by destabilizing banks and affecting water flow against debris, diminishing stream complexity with possible effects on aquatic life.	Antidegradation OAR 340-041-004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
		Trail Closure	
REC 24	Remove existing stream crossings or bridges. (See Road Decommissioning. BMPs.)	Coarse and Fine Sediment: Unmaintained crossings can plug,with debris, fail and deliver sediment to streams.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
REC 25	Position fill or waste material in a location that would avoid direct or indirect sediment discharges to streams or wetlands.	Coarse and Fine Sediment: Waste material is vulnerable to erosion.until vegetation is established, or erosion control measures are taken, resulting in sediment delivery to waterbodies ,floodplains and wetlands.	Turbidity OAR 340-041-0036
REC 26	Restored stream banks would be planted with native vegetation, mulched, and planted with water tolerant species where appropriate.	Coarse and Fine Sediment: Exposed soils are vulnerable to erosion in storm events and/ or periods of high stream flows, resulting in sediment delivery to waterbodies, floodplains and wetlands.	Turbidity OAR 340-041-0036
REC 27	Barricade and brush in closed trails with nearby vegetation.	Coarse and Fine Sediment: Unrestricted access to unmaintained or abandoned trails can result in rill and gully erosion and sediment delivery to waterbodies, floodplains, and wetlands.	Turbidity OAR 340-041-0036
Dispersed Recreation			
REC 28	Site camps for permitted group overnight camping would be greater than 100 feet from surface water.	Coarse and Fine Sediment: Soil disturbance close to streams can result in sedimentation. Lack of developed and maintained sanitation facilities poses a risk of fecal coliform contamination to waterbodies by direct contact or leaching.	Bacteria OAR 340-041-0009 Turbidity OAR 340-041-0036

Grazing

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-24. Best Management Practices For Grazing

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
G 1	Fence water developments, including springs and seeps, unless other methods are available. Pipe overflow away from the developed source area.	Coarse and Fine Sediment, Bacteria, Dissolved Oxygen, Temperature, and Biocriteria: Concentrated livestock use near/ within spring, seep areas resulting in overgrazing and subsequent loss of riparian vegetation, soil erosion, loss of shade and increases in summer stream water temperature, reduction in summer dissolved oxygen, delivery of bacteria and nutrients, with potential effects upon aquatic communities.	Antidegradation OAR 340-04l-0004 Bacteria OAR 340-041-0009 Biocriteria OAR 340-041-0011 Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
G 2	Do not locate salting areas within ¼ mile of permanent water sources or riparian management areas.	Coarse and Fine Sediment, Bacteria, Dissolved Oxygen, Temperature, and Biocriteria: Concentrated livestock use near/ within spring, seep areas resulting in overgrazing and subsequent loss of riparian vegetation, soil erosion, loss of shade and increases in summer stream water temperature, reduction in summer dissolved oxygen, delivery of bacteria and nutrients, with potential effects upon aquatic communities	Antidegradation OAR 340-04l-0004 Bacteria OAR 340-041-0009 Biocriteria OAR 340-041-0011 Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
G 3	Locate new livestock handling or management facilities (corrals, pens, or holding pastures) outside riparian management areas or 200 feet from waterbodies and on level ground where drainage would not enter surface waters. If existing livestock handling facilities inside riparian management areas do not meet water quality through use of BMPs, relocate or remove such facilities away from riparian management areas.	Coarse and Fine Sediment, Bacteria, Dissolved Oxygen, Temperature, and Biocriteria: Concentrated livestock use near/ within spring, seep areas resulting in overgrazing and subsequent loss of riparian vegetation, soil erosion, loss of shade and increases in summer stream water temperature, reduction in summer dissolved oxygen, delivery of bacteria and nutrients, with potential effects upon aquatic communities	Antidegradation OAR 340-04l-0004 Bacteria OAR 340-041-0009 Biocriteria OAR 340-041-0011 Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
G 4	Apply specific grazing strategies for riparian wetland areas, including timing, intensity, or exclusion for maintenance of proper functioning condition. Use one or more of the following features: Inclusion of the waterbodies, floodplains, and wetlands within a separate pasture. Fence or herd livestock out of waterbodies, floodplains, and wetlands for as long as necessary to allow vegetation to recover. Control the timing and intensity of grazing to keep livestock off streambanks when they are most vulnerable to damage and to coincide with the physiological needs of target plant species. Add more rest to the grazing cycle to increase plant vigor, allow streambanks to revegetate, or encourage more desirable plant species composition. Limit grazing intensity to a level that will maintain desired species composition and vigor. Permanently exclude livestock from those waterbodies, floodplains, and wetlands areas that are at high risk and havepoor recovery potential, and when there is no practical way to protect them while grazing adjacent uplands.	Coarse and Fine Sediment, Bacteria, Dissolved Oxygen, Temperature, and Biocriteria: Concentrated livestock use near/ within spring, seep areas resulting in overgrazing and subsequent loss of riparian vegetation, soil erosion, loss of shade and increases in summer stream water temperature, reduction in summer dissolved oxygen, delivery of bacteria and nutrients, with potential effects upon aquatic communities	Antidegradation OAR 340-04l-0004 Bacteria OAR 340-041-0009 Biocriteria OAR 340-041-0011 Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
G 5	Recover degraded waterbodies through adjustments to forage utilization levels, improved livestock distribution, and management through fencing, vegetation treatments, water source developments, or changes in season of use or livestock numbers.	Coarse and Fine Sediment, Bacteria, Dissolved Oxygen, Temperature, and Biocriteria: Concentrated livestock use near/ within spring, seep areas resulting in overgrazing and subsequent loss of riparian vegetation, soil erosion, loss of shade and increases in summer stream water temperature, reduction in summer dissolved oxygen, delivery of bacteria and nutrients, with potential effects upon aquatic communities	Antidegradation OAR 340-04l-0004 Bacteria OAR 340-041-0009 Biocriteria OAR 340-041-0011 Dissolved Oxygen OAR 340-041-0016 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036

Minerals Exploration and Development

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-25. Best Management Practices For Minerals Exploration And Development

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
All Minerals			
M 1	Locate, design, operate, and maintain settling ponds to contain sediment discharges.	Coarse and Fine Sediment: Sediment could be transported to nearby streams from improperly designed or overflowing settling ponds.	Turbidity OAR 340-041-0036
M 2	Where practical, use existing roads, skid trails, and stream crossings.	Coarse and Fine Sediment: New soil disturbance near streams and waterbodies may increase sediment delivery.	Turbidity OAR 340-041-0036
M 3	Storm proof all natural surface roads and trails when an operation halts for the wet season. See Roads and Landings section for guidelines.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to waterbodies, floodplains, and wetlands.	Turbidity OAR 340-041-0036
M 4	Locate and maintain sanitation facilities where overflow or discharges would not enter surface water. Where possible, locate these facilities outside of riparian management areas.	Bacteria: Bacterial pollution into waterbodies from improperly constructed sanitation facilities could be injurious to the health of humans and aquatic organisms.	Bacteria OAR 340-041-0009
M 5	If possible, locate structures and support facilities, at least 200 feet from water bodies, floodplains, and wetlands.	Coarse and Fine Sediment, and Temperature: Developed sites can channel water and sediment into nearby waterbodies. Loss of riparian vegetation due to development could reduce shade and increase water temperature.	Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
M 6	Design, locate, and construct stream crossings in conformance with practices described in Roads and Landings section.	Coarse and Fine Sediment: Earthwork near streams can expose erodible soils and result in sedimentation to streams.	Turbidity OAR 340-041-0036
M 7	If roads are used during wet seasons with potential for sediment delivery to stream channels, rock aggregate would be used to surface those roads, or other measures will be taken to prevent undue and unnecessary degradation	Coarse and Fine Sediment: Use of native surfaced roads during wet weather could result in unnecessary and undue degradation of water quality in nearby streams.	Turbidity OAR 340-041-0036
M 8	Prior to fall rains, reclaim all roads and trails constructed for exploratory purposes that are unnecessary for the mineral access.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to. waterbodies, floodplains, and wetlands.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
M 9	If possible, retain an undisturbed riparian buffer strip between mineral operations and water bodies, floodplains, and wetlands.	Coarse and Fine Sediment, and Temperature: Lack of a vegetative filter strip can destabilize streambanks and increase sediment delivery; lesser stream shade can elevate temperatures of streams and wetlands.	Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
M 10	Stockpile available topsoil for use during reclamation of the site. Stockpiled topsoil would be stabilized to prevent erosion and contamination of other resources in the area.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036
M 11	On access roads to mineral sites where no future entry is planned, reclaim these access roads. This may include tilling, water barring, blocking, re-contouring, fertilization, planting, mulching, and seeding.	Coarse and Fine Sediment: Soil erosion of exposed surfaces with potential transport to the channel, floodplain, or wetlands.	Turbidity OAR 340-041-0036
M 12	Reclaim depleted or closed mineral sites by stabilizing and contouring the mining area. Replace topsoil and mulch, seed, and plant.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036
Locatable Minerals			
M 13	Comply with seasonal restrictions on suction dredging identified in Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources when discharging to Oregon's surface waters.	Coarse and Fine Sediment: Suction dredging can deposit fine sediment in gravelsand is deleterious to fish and aquatic life.	Biocriteria OAR 340-041-0011 Turbidity OAR 340-041-0036
M 14	Plans of Operations and Notices, should contain waste products and prevent leaching contaminants from entering surface and ground water.	Toxic Substances: Mine generated waste and runoff can negatively impact surface or groundwater quality and impair aquatic habitat.	Biocriteria OAR 340-041-0011 Toxic substances OAR 430-041-0033
M 15	Reclaim mine waste after operations to ensure chemical and physical stability according to the BLM approved reclamation plan for the Plan of Operations or Notice requirements.	Toxic Substances: Mine generated waste and runoff can negatively impact surface or groundwater quality and impair aquatic habitat.	Toxic substances OAR 430-041-0033 Turbidity OAR 340-041-0036
M 16	Stabilize exposed soils by seeding, mulching, and planting with tree or brush species and provide for non- erosive drainage from disturbed areas that were constructed or renovated for mining activities.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
M 17	When operating during the wet season, stabilize disturbed areas that will not be mined or used for at least 30 days, if needed to prevent undue and unnecessary degradation.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036
Salable Minerals			
M 18	Locate stockpile sites on stable ground where the material would not move into waterbodies, floodplains, and wetlands.	Coarse and Fine Sediment: Placement of soil and rock stockpiles on unstable landforms can result in landslides with drainage of sediment-laden water to streams.	Turbidity OAR 340-041-0036
M 19	Locate, design, and construct salable mineral sites to minimize sedimentation to streams. Close roads, excavations and crusher pads in accordance with Roads and Landings section when the salable mineral site is depleted.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036
M 20	Avoid development of new quarries within Riparian Management Areas, unless water quality can be maintained. Expansion of existing quarries would be designed and implemented to maintain water quality.	Coarse and Fine Sediment, and Temperature: Developed sites can channel water and sediment into nearby waterbodies. Loss of riparian vegetation due to development could reduce shade and increase water temperature. Sedimentation in streams from road related runoff can impair aquatic habitat.	Biocriteria OAR 340-041-0011 Temperature OAR 340-041-0028 Turbidity OAR 340-041-0036
M 21	Use culverts and rip-rap for crusher pad drainage when necessary.	Coarse and Fine Sediment: Soil erosion of exposed surfaces with potential transport to the channel, floodplain, or wetlands.	Turbidity OAR 340-041-0036
M 22	Use erosion-reduction practices, such as seeding, mulching, silt fences, and woody debris placement, to limit erosion and transport of sediment to streams from quarries. Provide drainage from stockpiles and mineral sites that is dispersed over stable vegetated areas rather than directly into stream channels.	Coarse and Fine Sediment: Soil erosion of exposed surfaces with potential transport to the channel, floodplain, or wetlands.	Turbidity OAR 340-041-0036
Leasable Minerals			
M 23	Stabilize roads, drill sites, and excavation areas to a free draining and noneroding condition from disturbed areas that are constructed or renovated for leasable mineral activities (e.g., roads, drill sites, and excavation areas).	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
M 24	When operating during the wet season, stabilize disturbed areas that will remain inactive for at least 30 days.	Coarse and Fine Sediment: Bare soil is subject to surface erosion and potential sediment delivery to adjacent waterbodies.	Turbidity OAR 340-041-0036
M 25	Line all mud pits that contain drilling fluid to prevent leaking.	Coarse and Fine Sediment: Drilling fluid can leak from unlined pits to surface and groundwater resources.	Toxic substances OAR 430-041-0033 Turbidity OAR 340-041-0036
M 26	Limit drill site construction and access through riparian management areas to established roadways unless the operator submits a plan that demonstrates that impacts to water quality from the proposed action can be adequately mitigated.	Coarse and Fine Sediment: Vegetative removal in near stream areas of riparian management areas can decrease shade increasing stream temperatures, and increase sediment delivery by overland flow and disturbance to streambanks. Drilling and equipment fluids can negatively impact surface or groundwater quality and impair aquatic habitat.	Temperature OAR 340-041-0028 Toxic substances OAR 430-041-0033 Turbidity OAR 340-041-0036

Spill Prevention and Abatement

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-26. Best Management Practices For Spill Prevention And Abatement

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
Heavy Equipment Use			
SP 1	Inspect and clean heavy equipment as necessary prior to moving on to the project site, in order to remove oil and grease, noxious weeds, and excessive soil. Inspect hydraulic fluid and fuel lines on heavy-mechanized equipment for proper working condition. Where possible, maintain and refuel equipment a minimum of 100 feet away from streams and other waterbodies. In the event of a spill or release, all reasonable and safe actions to contain the material will be taken. Specific actions are dependent on the nature of the material spilled. Use spill containment booms or as required by DEQ. Have access to booms and other absorbent containment materials. Immediately remove waste or spilled hazardous materials (including but not limited to diesel, oil, hydraulic fluid) and contaminated soils near any stream or other waterbody, and dispose of it/them in accordance with the applicable regulatory standard. Notify Oregon Emergency Response System of any spill over the material reportable quantity, and any spill not totally cleaned up after 24 hours. Store equipment containing reportable quantities of toxic fluids ouside of riparian management areas.	Toxic Substances: Contamination of waterbodies from equipment leakage.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Toxic Substances OAR 340-041-0033

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
	Fuel and Chemical Transport		
SP 2	If more than 42 gallons of fuel or combined quantity of petroleum product and chemical substances, as project materials,would be transported to a project site, the following precautions will be implemented. 1. Plan a safe route and material transfer sites so that all spilled material will be contained easily at that designated location. 2. Plan an active dispatch system that can relay the information to appropriate resources. 3. Ensure a spill containment kit that can adsorb and contain 55 gallons of petroleum product and chemical substances is readily available. 4. Provide for immediate notification to OERS in the event of a spill. Have a radio-equipped vehicle lead the chemical or fuel truck to the project site. 5. Assemble a spill notification list that includes the district hazardous materials coordinator, DEQ, and spill clean-up contractors. 6. Construct a downstream water user contact list with addresses and phone numbers. 7. When operating within Source Water watersheds, pre-estimate water flow travel times through the watershed to predict downstream arrival times. 8. Be prepared to sample water and carry sample containers. Be prepared to assist OSP and ODFW assess wildlife impacts of any material spilled.	Toxic Substances: Chemical contamination of waterbodies.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Toxic Substances OAR 340-041-0033
	Spill Abatement		
SP 3	Spill Prevention, Control, and Countermeasure Plan (SPCC): All operators shall develop a modified SPCC plan prior to initiating project work if there is a potential risk of chemical or petroleum spills near water bodies. The SPCC plan will include the appropriate containers to be used and design of the material transfer locations. No interim fuel depot or storage location other than a manned transport vehicle.	Toxic Substances: Chemical or petroleum product routing to water bodies.	[40 CFR 112] 42 U.S. Gallons for reportable quantities not involving waterways, a visible sheen where waterways are involved

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
SP 4	Spill Containment Kit (SCK): All operators shall have a SCK as described in the SPCC plan on-site during any operation with potential for run-off to adjacent water bodies. The SCK will be appropriate in size and type for the oil or hazardous material carried by the operator.	Toxic Substances: Chemical or petroleum product routing to water bodies.	OAR-340-142-[0030]
SP 5	Operators shall be responsible for the clean-up, removal, and proper disposal of contaminated materials from the site.	Toxic Substances: Chemical or petroleum product routing to water bodies.	OAR-340-102-[inclusive] OAR-340-122-[inclusive]

Restoration

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Table I-27. Best Management Practices For Restoration

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
RST 1	Confine work in the stream channels to the low flow period unless a waiver is obtained from the permitting agencies.	Coarse and Fine Sediment: Concentrated turbidity and sedimentation potential due to channel disturbance during low flow conditions.	Accumulation of bottom deposits OAR-340-041-0007 Turbidity OAR-340-041-0036
RST 2	In stream channels that are sensitive to disturbance (e.g., meadow streams), do not drive heavy equipment in flowing channels and floodplains.	Coarse and Fine Sediment: Disturbance of stream channel and streambanks resulting in erosion, sedimentation, turbidity, and loss of channel stability.	Accumulation of bottom deposits OAR-340-041-0007 Turbidity OAR-340-041-0036
RST 3	In well armored channels that are resistant to damage (e.g., bedrock, small boulder, or cobble dominated), consider conducting the majority of heavy-equipment work from within the channel, during low streamflow, to minimize damage to sensitive riparian areas.	Coarse and Fine Sediment, and Temperature: Disturbance of floodplain and streambanks resulting in erosion, sedimentation, turbidity, and loss of stream shade, resulting in a potential increase of stream temperature.	Turbidity OAR-340-041-0036 Water Temperature OAR-340-041-0028
RST 4	Design access routes for individual work sites to reduce exposure of bare soil and extensive streambank shaping.	Coarse and Fine Sediment: Soil erosion with potential transport to the channel and floodplain.	Turbidity OAR-340-041-0036
RST 5	Limit the number and length of equipment access points through riparian management areas.	Coarse and Fine Sediment, and Temperature: Disturbance of floodplain and streambanks resulting in erosion, sedimentation, turbidity, and loss of stream shade, resulting in a potential increase of stream temperature.	Turbidity OAR-340-041-0036 Water Temperature OAR-340-041-0028
RST 6	Limit the amount of streambank excavation to the minimum necessary to ensure stability of enhancement structures. Provide isolation from flowing water during excavation. Place excavated material above the flood prone area and cover or place a berm to avoid its reentry into the stream during high flow events.	Coarse and Fine Sediment: Sedimentation during high flow events resulting in erosion, sedimentation and turbidity.	Accumulation of bottom deposits OAR-340-041-0007 Turbidity OAR-340-041-0036
RST 7	Inspect all mechanized equipment daily for leaks and clean as necessary to help ensure that toxic materials, such as fuel and hydraulic fluid, do not enter the stream.	Oil, Gas, and Chemical Fluids: Direct entry of oil and gas into waterbody, resulting in effects on aquatic life	Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Biocriteria OAR 340-041-0011

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
RST 8	Equipment will not be stored in stream channels when not in use.	Oil, Gas, and Chemical Fluids: Direct entry of oil and gas into waterbody resulting in effects on aquatic life	Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Biocriteria OAR 340-041-0011
RST 9	When using heavy equipment in or adjacent to stream channels during restoration activities, develop and implement an approved spill containment plan that includes having a spill containment kit on-site and at previously identified containment locations.	Oil, Gas, and Chemical Fluids: Direct entry of oil and gas into waterbody resulting in effects on aquatic life	Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Biocriteria OAR 340-041-0011
RST 10	Refuel equipment, including chainsaws and other hand power tools, at least 100 feet from water bodies (or as far as possible from the water body where local site conditions do not allow a 150-foot setback) to prevent direct delivery of contaminants into a water body.	Oil, Gas, and Chemical Fluids: Direct entry of oil and gas into waterbody resulting in effects on aquatic life	Statewide Narrative Criteria Oil and Floating Solids OAR 340-041-0007 Biocriteria OAR 340-041-0011
RST 11	Use waterbars, barricades, seeding, and mulching to stabilize bare soil areas along project access routes prior to the wet season.	Coarse and Fine Sediment: Excessive turbidity and sedimentation to downstream areas due to erosion of disturbed soils.	Turbidity OAR-340-041-0036
RST 12	Rehabilitate and stabilize disturbed areas where soil will support seed growth by seeding and planting with native seed mixes or plants, or using erosion control matting.	Coarse and Fine Sediment: Excessive turbidity and sedimentation to downstream areas due to erosion of disturbed soils.	Turbidity OAR-340-041-0036
RST 13	When replacing culverts, install grade control structures (e.g., boulder vortex weirs or boulder step weirs) where excessive scour would occur.	Coarse and Fine Sediment: Excessive turbidity and sedimentation to downstream areas due to erosion of upstream sand/gravel/cobble deposits.	Accumulation of bottom deposits OAR-340-041-0007 Turbidity OAR-340-041-0036
RST 14	Rehabilitate headcuts and gullies.	Coarse and Fine Sediment: Excessive turbidity and sedimentation to downstream areas due to erosion of upstream sand/gravel/cobble deposits.	Accumulation of bottom deposits OAR-340-041-0007 Turbidity OAR-340-041-0036
RST 15	Install turbidity control structures (e.g., isolation, diversioin, or silt curtains) immediately downstream of in-stream restoration work areas. Remove these structures following completion of turbidity generating activities.	Coarse and Fine Sediment: Excessive turbidity to downstream areas generated during instream structure placement.	Turbidity OAR-340-041-0036

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
RST 16	Klamath Falls: During restoration projects involving juniper control or prescribed burns, design projects so that adequate soil cover remains (either by leaving cut trees in place for many years or by lopping and scattering branches); and adequate herbaceous seed source or seed bed is available (either naturally or through seeding), and ensure that subsequent management of the site addresses other limiting factors caused by management (e.g., livestock use or recreation).	Coarse and Fine Sediment: Soil erosion with potential transport to the channel and floodplain.	Turbidity OAR-340-041-0036

Medford District-Specific BMPs

See *Summary of Oregon Water Quality Standards* for additional details about the standards and regulations that are associated with the best management practices.

Soils of concern highlighted in the Medford-specific BMPs have a high potential for surface erosion and landslides. They include granitic, schist, and pyroclastic soils. These soils are scattered throughout the Medford District; however, the largest concentration of soils formed from decomposed schist and/or granite parent material occurs in Evans, Snow, Sugar, and Meadow Creeks, upper portions of Williams Creek, and headwaters of Birdseye Creek. Soils formed in highly weathered pyroclastic parent materials are predominantly in the foothills of the Cascades.

Table I-28. Soil Categories Of Concern For The Medford District

Category	Description Of Soil Categories
Mass Movement	These sites consist of deep seated, slump, or earth flow types of landslides with undulating topography and slope gradients generally less than 60 percent. Soils are derived from volcanic tuffs or breccias.
Surface Erosion	These sites have soil surface horizons that are highly erodible. Soils are derived from granite or schist bedrock.

Table I-29. Additional Medford Best Management Practices

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
Timber Harvest: Cable Yarding			
MFO 1	Use full suspension whenever possible on soils identified in the surface erosion category. Use partial suspension on these soils if full suspension is not possible. Restrict yarding to the dry season on soils identified in the mass movement category and on soils in the surface erosion category if full suspension is not possible.	Fine Sediment: Yarding corridors on soils of concern can result in soil exposure with potential for transport and delivery of sediment to waterbodies. Yarding corridors can channel water and sediment into waterbodies.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Timber Harvest: Ground-Based Yarding			
MFO 2	Prohibit ground-based yarding equipment on soils identified in the surface erosion and mass movement categories. Exclude tilling on soils identified in the surface erosion and mass movement categories.	Fine Sediment: Displacement and exposure of soils through equipment operation with potential delivery of sediment to waterbodies resulting in sedimentation and turbidity.	Antidegradation OAR 340-041-0004(1) Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Fire and Fuels Management: Pile and Burn			

BMP Number	Best Management Practices	Input Variables and Causal Mechanisms	Water Quality Standards and Regulations
MFO 3	Prohibit mechanical piling on soils identified in the surface erosion and mass movement categories. Burn handpiles on soils identified in the surface erosion categories only if they interfere with silvicultural operations.	Fine sediment: Ground disturbance reduces infiltration and increases surface runoff with subsequent soil movement. Bare soil is subject to surface erosion.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Fire Fuels Management: Mechanical and Manual Fuel Treatments			
MFO 4	Prohibit ground-based equipment on soils identified in the surface erosion and mass movement categories.	Coarse and Fine Sediment: Ground-based equipment reduces infiltration and increases surface runoff with subsequent soil movement.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Wildfire: Suppression			
MFO 5	Limit the use of tractors and other major surface-disturbing activities on all soils identified in the surface erosion and mass movement categories.	Fine Sediment: Soils of concern are highly susceptible to surface erosion when disturbed.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036
Rights-of-Way			
MFO 6	Avoid facility construction on soils identified in the surface erosion and mass movement categories unless water quality can be maintained. Locate rights-of-ways to minimize surface disturbance on soils identified in the surface erosion and mass movement categories.	Fine Sediment: Soils of concern are highly susceptible to surface erosion when disturbed.	Antidegradation OAR 340-041-0004(1) Biocriteria OAR 340-041-0011 Statewide Narrative OAR 340-041-0007(1) and (13) Turbidity OAR 340-041-0036

Summary of Oregon Water Quality Standards

This section summarizes the Oregon standards and regulations for water quality that are associated with the best management practices.

Statewide Narrative Criteria

The following are the Oregon administrative rules (OARs) for the statewide narrative criteria for water quality by name, number, and descriptive excerpt.

Antidegradation (OAR 340-04l-0004)

"The purpose of the Antidegradation Policy is to guide decisions that affect water quality such that unnecessary further degradation from new or increased point and nonpoint sources of pollution is prevented, and to protect, maintain, and enhance existing surface water quality to ensure the full protection of all existing beneficial uses."

Note: The antidegradation policy applies to all 303(d) listed waterbodies when a project could further degrade the water quality.

Statewide Narrative Criteria Biological Criteria (OAR 340-041-0007)

"(11) The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or that are injurious to health, recreation, or industry may not be allowed."

Statewide Narrative Criteria Oil and Floating Solids (OAR 340-041-0007)

"(14) Objectionable discoloration, scum, oily sheens, or floating solids, or coating of aquatic life with oil films may not be allowed."

Statewide Narrative Criteria Road Building Waste Materials (OAR 340-041-0007)

"(9) Road building and maintenance activities must be conducted in a manner so as to keep waste materials out of public waters and minimize erosion of cut banks, fills, and road surfaces."

Statewide Narrative Criteria Sediment, Adverse Deposits(OAR 340- 041-0007)

"(13) The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed."

Statewide Narrative Criteria Summary (OAR 340-041-0007)

"(1) Notwithstanding the water quality standards contained in this Division, the highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels."

Statewide Narrative Criteria Toxics (OAR 340-041-0007)

"(12) The creation 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 may not be allowed."

Statewide Numeric Criteria

The following are the Oregon administrative rules (OARs) for the statewide numeric criteria for water quality by name, number, and descriptive excerpt.

Bacteria (OAR 340-041-0009)

"(1) Numeric Criteria: Organisms of the coliform group commonly associated with fecal sources (MPN) or equivalent membrane filtration using a representative number of samples) may not exceed the criteria described in paragraphs (a) and (b) of this paragraph: (a) Freshwaters and Estuarine Waters Other than Shellfish Growing Waters:

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

(B) No single sample may exceed 406 *E. coli* organisms per 100 milliliters."

Biocriteria (OAR 340-041-0011)

"Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities."

Dissolved Oxygen (OAR 340-041-0016)

"Dissolved oxygen (DO): No wastes may be discharged and no activities must be conducted that either alone or in combination with other wastes or activities will cause violation of the following standards: The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply:

(1) For waterbodies identified as active spawning areas in the places and times indicated on the following tables and figures set out in OAR 340-041-0101 to 340-041-0340: Tables 101B, 121B, 180B, 201B and 260B, and Figures 130B, 151B, 160B, 170B, 220B, 230B, 271B, 286B, 300B,310B, 320B, and 340B, (as well as any active spawning area used by resident trout species), the Rules of this Division as last modified by the EQC 05/20/2004 following criteria apply during the applicable spawning through fry emergence periods set forth in the tables and figures:
- (a) The dissolved oxygen may not be less than 11.0 mg/l. However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 mg/l or greater, then the DO criterion is 9.0 mg/l;
- (b) Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0 mg/l or 9.0 mg/l criteria, dissolved oxygen levels must not be less than 95 percent of saturation;
- (c) The spatial median intergravel dissolved oxygen concentration must not fall below 8.0 mg/l.

(2) For waterbodies identified by the Department as providing cold-water aquatic life, the dissolved oxygen may not be less than 8.0 mg/l as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/l, dissolved oxygen may not be less than 90 percent of saturation. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen may not fall below 8.0 mg/l as a 30-day mean minimum, 6.5 mg/l as a seven-day minimum mean, and may not fall below 6.0 mg/l as an absolute minimum (Table 21);

(3) For waterbodies identified by the Department as providing cool- water aquatic life, the dissolved oxygen may not be less than 6.5 mg/l as an absolute minimum. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen may not fall below 6.5 mg/l as a 30-day mean minimum, 5.0 mg/l as a seven-day minimum mean, and may not fall below 4.0 mg/l as an absolute minimum (Table 21);

(4) For waterbodies identified by the Department as providing warm- water aquatic life, the dissolved oxygen may not be less than 5.5 mg/l as an absolute minimum. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen may not fall below 5.5 mg/l as a 30-day mean minimum, and may not fall below 4.0 mg/l as an absolute minimum (Table 21);

(5) For estuarine water, the dissolved oxygen concentrations may not be less than 6.5 mg/l (for coastal waterbodies)."

Temperature (OAR 340-041-0028)

"A. The seven-day-average maximum temperature of a stream identified as having salmon and steelhead spawning use may not exceed 55.4 degrees Fahrenheit.

B. The seven-day-average maximum temperature of a stream identified as having core cold water habitat use may not exceed 60.8 degrees Fahrenheit.

C. The seven-day-average maximum temperature of a stream identified as having salmon and trout rearing and migration use may not exceed 64.4 degrees Fahrenheit.

D. The seven-day-average maximum temperature of a stream identified as having a migration corridor use may not exceed 68.0 degrees Fahrenheit."

Turbidity (OAR 340-041-0036)

"No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity."