Little Fall Creek / Hills Creek

Watershed Analysis

February 1997

Weyerhaeuser

Glossary of Terms

active channel The bed, banks, and floodplain of a stream subject to modifications by streamflows. Geometrically synonymous with the bankfull channel.

aggradation A disequilibrium stream channel process that raises the elevation of a reach of an active stream channel by depositing bedload.

alluvial Describing material, usually sediment, deposited by a stream or running water.

anadromous fishes Fish that spend the adult phase of their life cycle in salt water and move up fresh water streams and rivers to spawn.

andesite A dark to medium-colored, fine-grained extrusive rock. Rocks are generally hard and resistant to erosion but are often mixed with less resistant materials.

avulsion The process by which a channel changes course by a sudden diversion. The periodicity of avulsion is controlled by the rate of topographic change, fluctuations in discharge and occurrence of triggering events.

bankfull The cross-sectional elevation of the channel corresponding to the top of the floodplain.

basalt A dark-colored, fine-grained igneous (extrusive) rock. Rocks are generally hard and resistant to erosion but are often mixed with less resistant materials.

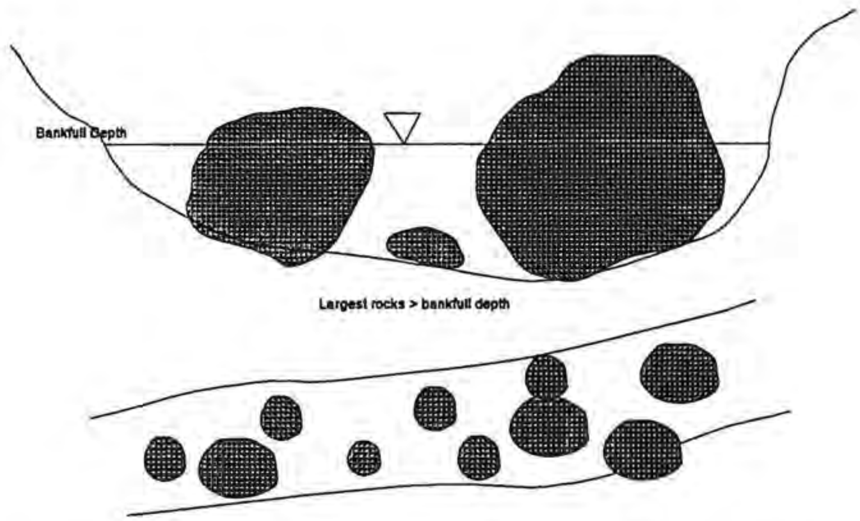
base level The elevation below which a reach of a stream cannot degrade its bed.

bed roughness The frictional resistance to flow in a river or stream system.

bedload mobility The material transported along the floor of a flowing fluid by rolling, sliding or saltation.

cascades A series of small closely spaced waterfalls or steep rapids (channel gradient usually 8-20%). Largest rock in the channel exceeds bankfull depth. Infrequent, small pools (<1 channel width per pool). Low in-channel storage of sediment (high transport relative to supply).

Illustration:



channel migration zone The area that streams have recently occupied (in the last few years or, less often, decades), and would reasonably be expected to occupy again in the near future.

colluvium A deposit of rock fragments and soil material accumulated within depressions or at the base of steep slopes as the result of gravitational action.

confinement The relative ratio of bankfull (active) channel width to valley width where the valley margins may be defined by hillslopes or terrace scarps. This ratio, when assessed in the context of stream gradient, provides a qualitative index of available shear stress as a function of water surface elevation in the channel.

> Low confinement (LC) = VW > 4 CW
> Moderate confinement (MC) = 2 CW < VW < 4 CW
> Tight Confinement (TC) = VW < 2 CW.
>
> *Example:* Channels with wide floodplains (LC) may shift laterally over the valley bottom, changing course or pattern in response to disturbance but channels confined by bedrock valley walls (TC) can only respond by bedrock modification or channel armoring

dam-break flood (DBF): A dam break flood (DBF) occurs when a natural constriction or dam in a stream channel fails and causes a downstream surge of water and debris caused by the sudden breaching of an impoundment in a stream channel; a form of debris torrent. These dams can be caused by rockfall into a channel, a small slope movement blocking a channel, the deposit of a debris flow, or a debris jam, beaver activity, or a number of other natural mechanisms, and can cause a flood up to two orders of magnitude larger than normal storm runoff floods. These mass wasting events are unusual in that they initiate in areas of generally low slopes, unlike most mass wasting events. These extreme hyperconcentrated (water > sediment) floods can occur in 1st through 6th order valleys, in both natural and managed landscapes.

debris flood (debris-laden flood) A peak flow event comprised of large volumes of organic debris that can scour and erode the bed and banks of the stream. The woody material can be a component of the waning surge of an upstream debris flow. Distinguished from debris flows and dam break floods by the lack of viscous flow.

debris torrent (DT) Debris flow or dam-break flood, undifferentiated. The effects of debris flow and dam-break floods can appear superficially similar (particularly on air-photos), although the two processes differ in initiation, composition, and travel characteristics. This term is used when it is not possible to distinguish between the two, either because of poor resolution on air-photos or inconclusive evidence in the field.

deep-seated failure Landslide involving deep regolith, weathered rock, and/or bedrock, as well as surficial (pedogenic) soil. As used here, deep-seated landslides commonly include large (acres to hundreds of acres) slope features, associated with geologic materials and structures. In watershed analysis, they are divided into:

- **large-persistent deep-seated failures (LPD)** Commonly slump-earthflows involving large areas of hillside; found in natural and managed landscapes, recognizable over long periods of time, and almost always predate land use. These occur due to climatic changes (periods of high rainfall) or events such as strong earthquakes, geologic weakness, or channel incision. These large persistent deep seated slides appear to have been active at some time in the past, however, they do not appear to have moved on the large scale for many years, perhaps centuries.
- **small-sporadic deep-seated failures (SSD)** Commonly smaller slumps that can be triggered at irregular intervals (by storms or earth movement), and can weather to the point where they are indiscernible.

degradation A disequilibrium stream channel process that lowers the elevation of a reach of an active stream via incision.

dike Long, thin intrusive igneous rock units that cuts across the structure of adjacent rocks.

Illustration:

earthflow: Deep-seated landslide of broken soil and rock, dominated by slow movement (flow-like); produce linear areas of hummocky, disjointed terrain. Earthflow activity is favored in deep, cohesive soil, clay-rich bedrock, or slumped material, and is largely controlled by seasonal (or longer) fluctuations of pore-water pressure.

ephemeral stream A stream that flows only briefly in direct response to rainfall or snowmelt. Its streambed remains above the groundwater table.

extrusive A type of igneous rock that has been erupted onto the surface of the earth. Extrusive rocks include lava flows (which are often composed of basalt and andesite) and pyroclastic material such as volcanic ash.

floodplain The area immediately adjacent to the channel being constructed by the river in the present climate and flooded at high discharge. The level of the floodplain is commonly inferred to be the level of the bankfull stage and is commonly misinterpreted as being coincident with low stream terraces.

flotation load The portion of mobile particles, usually woody debris, in a stream that remain suspended in the water column due to low specific gravities relative to water. A type of suspended load.

geomorphic General shape or features of the landscape.

headwall A steep, wall-like cliff at the back of a hollow or hillslope depression. In reference to slope stability, the term refers to the stability of the entire hollow or depression.

hydrologic maturity Condition of a forest stand in which hydrologic processes operate as they do in a mature or old-growth forest. In particular, snow accumulation is typically lower in thick, dense forest (at middle and lower elevations) than in openings, due to interstorm melt of snow caught in the canopy; and snowmelt is slower, due to decreased wind-aided flux of sensible and latent heat.

intermittent stream A stream that flows during part of the year. Its water is derived from rainfall, snowmelt, or occasional groundwater discharge into the stream channel.

intrusive A type of igneous formed by the injection of magma (molten rock) into pre-existing rock.

iteroparous Capable of repeated reproduction (characteristic of most fishes)

landslide Any mass-movement process characterized by downslope transport of soil and rock, under gravitational forces, by sliding or deformation within a discrete failure zone. Also used to refer to the resultant landform. In common usage, can also include other forms of mass wasting not involving sliding (rockfall, etc.)

large woody debris (LWD) recruitment Large woody debris delivered by the fall of streamside trees, or delivery from upstream sources by stream transport.

longitudinal profile A topographic profile along a valley or stream

mafic Said of an igneous rock composed chiefly of dark, ferromagnesian minerals (iron and magnesium rich minerals).

mass wasting General term for dislodgment and downslope transport of soil and rock under direct gravitational forces (i.e., without major action of water, wind, or ice); mass movement. In watershed analysis, this class of erosion processes is divided into three categories: shallow-rapid landslides, deep-seated failures, and debris torrents.

migration Any mass movement from one habitat to another with characteristic regularity in time according to stages of life history.

peak flow event Maximum instantaneous stream discharge during runoff, commonly caused by an individual rainstorm, rain-on-snow, or spring snowmelt.

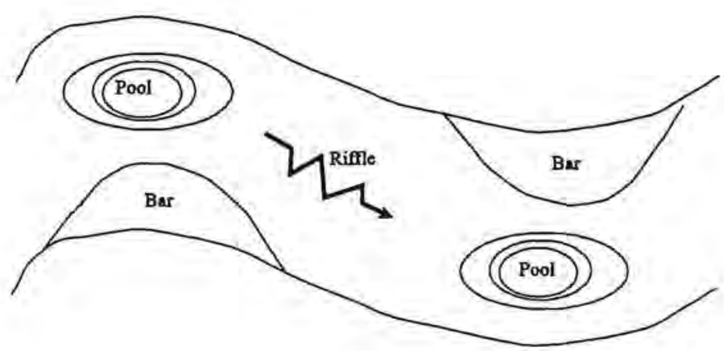
perennial stream A stream that flows continuously as a result of surface runoff and influx of groundwater.

piedmont A plain that slopes away from the base of a mountainous escarpment.

plane-bed channel A channel that lacks well-defined bedforms and are characterized by long stretches of relatively planar channel bed that may be punctuated by occasional channel spanning rapids. Channel gradient is commonly between 1 and 3%, and can have a wide range of confinement (LC to TC). Additions of large woody debris may provide sufficient flow convergence and divergence to cause pool development and transform the channel to a forced pool-riffle morphology. Rapid aggradation (sediment deposition) can change the channel to a braided morphology.

pool-riffle channel A channel with an undulating bed that defines a sequence of bars, pools and riffles. Channel gradient is commonly between 1 and 3%, and generally unconfined. Regular spacing of pools at 5-7 channel widths per pool. Maximum diameter of substrate much less than bankfull depth. Low relative transport capacity makes them particularly sensitive to changes in sediment supply and discharge.

Illustration:



potamodromous A type of fish migration which occurs wholly in freshwater.

Quaternary The second period of the Cenozoic era, following the Tertiary; also, the corresponding system of rocks. It began 1.6 million years ago and extends to the present.

Rain-on-snow zone Area (generally defined as an elevation zone) where it is common for snowpacks to be partially or completely melted during rainstorms several times during the winter.

riparian function Activity relating to the LWD recruitment and stream-shading functions provided by riparian vegetation.

riparian zone Area surrounding a stream, in which ecosystem processes are within the influence of stream processes.

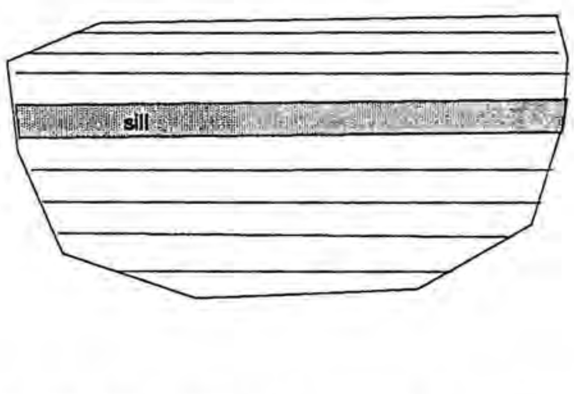
saltation The process of particle transport in stream channels via bouncing along the stream bed. Particle position thus alternates between suspension in the flow and short-term resting on the channel bed.

semelparous Capable of one reproduction (characteristic of salmon).

shallow-rapid landslide (SR): Landslide produced by failure of the soil mantle (typically to a depth of one or two meters, sometimes including some weathered bedrock), on a steep slope. The debris moves quickly (commonly building up and developing into a debris torrent), leaving an elongate, spoon-shaped scar. Shallow-rapid landslides typically occur in this basin on steep, concave slopes where thin soil and/or decomposed rock overlie a more cohesive bedrock. These features are also known as debris slides, debris avalanches, or planar failures and occur within the soil, rarely incorporating bedrock. Soil thickness is typically small compared to the length of the landslide. The material of the slide moves rapidly down slope along a surface that is roughly parallel to the ground surface. This mass wasting type includes road fill failures. The debris commonly breaks apart to form a debris avalanche and, depending on the location, can deliver sediment to streams and damage roads. Fill failures lead to shallow rapid failures, and when in young (<20 year) conifer stands that do not have adequate buttressing strength. These shallow rapid failures can propagate down the steep slopes and when the accumulated mass enters a stream channel and combines with great amounts of water, the resulting slurry can turn into a highly destructive debris torrent. Debris torrents scour the channels of the steeper slopes, and then deposit huge amounts of fine and coarse sediment onto the lower gradient slopes within the stream channels, providing an instantaneous, and long term sediment source. Shallow-rapid landslides not associated with roading, most often occur in convergent topography on steep slopes in areas where topography or bedrock structure concentrates drainage such as in swales or draws. The main factor contributing to the occurrence of these types of slides are slope, saturation of soil and loss of root strength. Forest practices can effect these factors and influence the occurrence of shallow-rapid landslides.

sill An igneous intrusion that parallels the planar structure of the surrounding rock (like a dike but dikes can bisect rock but a sill has to parallel the planes of the rock into which it is intruded).

Illustration:



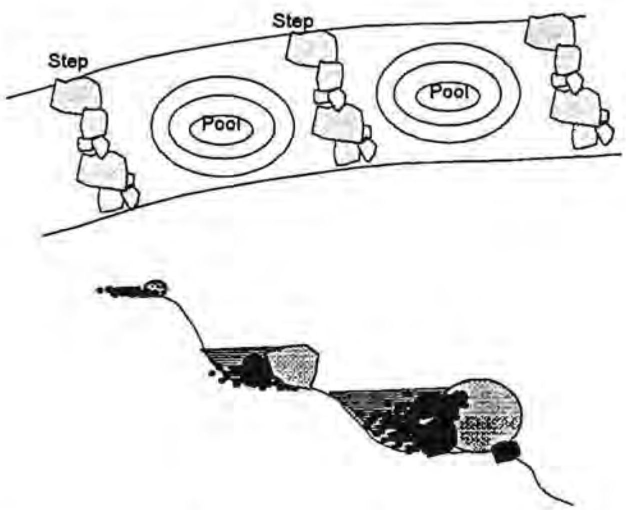
slump: Deep, rotational landslide, generally producing coherent movement (back-rotation) of blocks over a concave failure surface. Typically, slumps are triggered by increased pore-water pressure in mechanically weak materials (deep soil or clay-rich rock).

slump-earthflow: Landslide exhibiting characteristics of both slumps and earthflows; typically the upper part moves by slump (rotation of blocks), while the lower portion moves by flow (hummocky terrain).

snow-water equivalent (SWE) Amount of liquid water (expressed as depth) derived by melting a snowpack.

step-pool channels A series of steps separating pools. The steps may be composed of LWD or accumulations of sediment. A regular spacing of pools at 1-4 channel widths per pool. Heterogeneous bed mixture. Low sediment supply, high discharge.

Illustration:



strath An extensive terrace-like remnant of a broad valley floor that has undergone dissection, e.g. a river terrace along a valley wall or incised bedrock.

stream power The power available to transport bedload. It consists of those variables (such as discharge and gradient) that, if increased, favor bedload transport and fluvial degradation.

stream terrace A relatively flat surface adjacent to a stream or river that represents an abandoned floodplain (low terraces are frequently confused with the floodplain). Terrace surfaces can rise one to tens of meters above the active channel bed.

step-pool channel Channels characterized by large particles (boulders or woody debris) organized into discrete channel spanning accumulations that form a series of steps separating pools. Longitudinal gradients are typically 4 to 8 percent.

Tertiary The first period of the Cenozoic era (after the Cretaceous of the Mesozoic era and before the Quaternary), thought to have covered the span of time between 65 million and 2 million years ago; also, the corresponding system of rocks.

toe The downslope edge of a landslide or slump.

Little Fall Creek / Hills Creek

Watershed Analysis

PART I

Section B

Causal Mechanism Reports
and
Prescriptions

May 1997

Weyerhaeuser

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INTRODUCTION

The prescriptions included in the watershed analysis report were developed by the prescription team to address triggering mechanisms having the potential to adversely affect fish and water resources in the Little Fall Creek/Hills Creek Watershed Administrative Unit (WAU) of Lane County, Oregon.

The Little Fall Creek/Hills Creek WAU consists of 8 sub-basins (52,235 acres) tributary to the Willamette River. The watershed is primarily forestland owned by Weyerhaeuser (60%), Willamette National Forest (12%), BLM (10%), Willamette Industries (4.5%) and other private landowners (13.3%).

The Watershed Synthesis portion of this document has described watershed characteristics and resource sensitivities (watershed *analysis*). This section addresses prescriptions, which are watershed *management* techniques.

LITTLE FALL CREEK / HILLS CREEK TEAM MEMBERS

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Start Date: November 1996

Initiated by: Weyerhaeuser Company
Completion Date: May 1997

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MANAGEMENT SUMMARY

Overview

Management prescriptions have been prepared to address all triggering mechanisms identified in the Causal Mechanism Reports. In most cases, we have developed several alternatives to match prescriptions to the site. The specific prescription call will be made by the appropriate land manager in the field. Our intent is to maintain landowner flexibility to integrate protective and/or preventative measures into management activities.

Note that prescriptions have been developed only for forestland. We have not addressed resource sensitivities and triggering mechanisms resulting from non-forestry activities. Note also that while Willamette Industries participated in this watershed analysis, the prescriptions were written for Weyerhaeuser forestlands.

The key sensitivities for the Little Fall Creek/Hills Creek Watershed are:

1. In-Stream Structure (lack of large woody debris to provide high quality habitat)
2. Fine Sediment (naturally high background rates and management related inputs primarily from roads)

Prescriptions, implementation, and associated resources are focused on these key sensitivities. We have prepared two maps to aid in implementation (see **Map RX1** *Prescription Sensitivities* and **Map RX2** *Prescription Summary, Road Maintenance*; both maps are located in Prescription Documents section).

Monitoring has been designed to evaluate effectiveness of these management techniques. In addition, monitoring and future evaluations will be used to periodically check overall "health" of the watershed, including areas that are currently in the desired state and not identified as resource sensitivities (e.g. to ensure that stream temperatures stay within acceptable ranges).

Triggers have been established to re-open the process if the prescriptions do not yield the desired results. Trigger parameters originate in the mid and long-term trends tracked in the monitoring process. Due to natural variability and slow rates of change, some parameters must be tracked for a minimum of five years before a trend can be established.

The team believes that, over time, these prescriptions will protect water quality and fish habitat. Thus, we expect continuous improvement in fish habitat and water quality in this watershed.

KEY SENSITIVITIES

1. Large Woody Debris (LWD)

Resource Objective:	Re-establish LWD recruitment potential by developing self-sustaining riparian areas that support large conifer for recruitment to the stream channel.
Prescription: Description:	• Manage riparian areas to provide a long-term source of coniferous large woody debris. ◊ Focus <u>riparian</u> enhancement work where the need and potential for success are greatest (e.g. hardwood dominated riparian stands occupying sites that would or previously did support conifers). • The Oregon Forest Practices Act, including the 1994 stream protection rules, is the basis for prescriptions.
Objective:	• Increase conifer LWD in streams.
Monitoring:	Site Specific: • Monitor the effectiveness of any stream enhancement projects in the Little Fall Creek / Hills Creek Watershed that may be placed as a result of this watershed analysis or from projects outside of this analysis. • Where applicable, use ODF&W fish survey information as an indicator of habitat improvement. Broad Scale: • Repeat photo assessment of LWD recruitment potential on fish-bearing streams using watershed methodology at ten year intervals. Evaluate this after twenty years for effectiveness and adjust as necessary.

Trigger for Prescription Review:	• Long-term trend for LWD/pools is decreasing (from watershed analysis stream habitat protocol) without a catastrophic natural event that would explain the trend. • Long-term trend for LWD recruitment potential is flat or decreasing (from watershed analysis stream habitat protocol) without a catastrophic natural event that would explain the trend.
Situation / Prognosis:	• Large conifer for current recruitment is less than optimum. Currently 50% of the WAU has low riparian recruitment potential. However, many areas are stocked with young conifer, or mixed conifer and hardwood stands, providing good long-term recruitment potential. • Pools created by LWD are considered low in the anadromous migration corridor of Little Fall Creek. • Short-term increases in LWD would require active placement or a catastrophic natural event (i.e. Columbus Day storm). • We expect an increase in LWD input to the system. Significant increase due to natural input is not expected for several decades (50 to 100+ years).
Overall/long-term measures of success:	• Higher density of large resident fish. • Improved complexity (pool and cover) for summer rearing habitat used by salmonids.

2. Fine Sediment

Resource Objective:	Maintain high quality instream habitat for aquatic biota. Minimize contamination of spawning gravels by fine sediments.
Prescription:	
Description	• Reduce fine sediment generated by management activities. Priority areas for improvements focus on roads. ◊ The Weyerhaeuser Road Maintenance Manual forms the basis for prescriptions (see Prescription Documents section).
Objective	• Minimize sediment generated by management activities. • Prevent sediment generated by management activities from entering streams.
Monitoring:	Site Specific: • Re-do the road inventory and sediment model for the watershed in 10 years. Broad Scale: • Track location and reasons for culvert failures. • Incorporate into GIS the location and reason, if known, of any mass wasting failure that delivers.

Trigger for Prescription Review:	• Fine sediment levels trending upward over 10 year period from original road inventory sediment predictions.
Situation / Prognosis:	• Fine sediment levels are naturally high in this WAU due to high clay content soils, particularly in the Hills Creek area. • Turbid run-off is common in Hills Creek, due to the smectite soils, independent of management activities. • Management-generated sediment entering streams is expected to be decreasing.
Overall/long-term measures of success:	• Reduced fine sediment contamination of spawning gravels.

IMPLEMENTATION

Prescription implementation will begin in May, 1997.

There is a process in place in the region to review upcoming harvest activities for prescription sensitivities. Any potential watershed issues are communicated through this process to the appropriate field personnel prior to the start of activity.

Map RX1 (*Prescription Sensitivities*) and Map RX2 (*Prescription Summary, Road Maintenance*) are two maps that have been developed to aid in the implementation of prescriptions in this watershed.

The Region plans to conduct annual reviews of watershed management. These reviews will provide:

- Documentation of prescription activities carried out during the previous year (e.g. brief description of activities).
- Documentation of monitoring results, if any, from the previous year.
- Planning and coordination of prescription activities for the coming year.

Little Falls Creek / Hills Creek Watershed reviews are targeted for June of each year (starting June 1998).

WATERSHED CHARACTERISTICS SUMMARY

Watershed Administrative Unit: Little Fall Creek/Hills Creek

Drainage System:	Middle Fork Willamette tributary to Willamette
Location:	Hills River Mile 195 of Middle Fork Willamette Little Fall Creek RM 3.5 of Fall Creek (which enters Middle Fork Willamette at RM 198.5)
Basin Area:	52,235 acres (81.6 square miles)
Climate:	Mainly rain, snow at elevation
Mean Annual Precipitation:	40" in lowlands, up to 90" uplands
Elevation Range:	540' - 4200'
Geology:	Diverse assemblage of Tertiary age volcanic rocks that have undergone little structural deformation. Lithologies include tuffs, breccias, andesites, and basalts. Quaternary alluvium fills the valleys.
Sub-basin Stream Density (mi/mi^2)	average 5.42
Sub-basin Road Density (mi/mi^2)	avg 3.97 mi/mi^2
Vegetation (dominant)	2nd growth Douglas fir
Vegetation (sub-dominant)	Hemlock, red alder
Land Use:	Forest management, agriculture, rural residences
Major Land Owners:	Weyerhaeuser Company, Willamette National Forest, BLM, Willamette Industries and other private landowners
Water Supplies:	No public
Salmonid Resources:	Anadromous: Chinook salmon (spring), Steelhead (summer and winter) Resident: Rainbow trout, Coastal cutthroat trout, Mountain whitefish

Mass Wasting Resource Sensitivity A1:

Road-related failures in steep, concave slopes; high mass wasting hazard potential.

CAUSAL MECHANISM REPORT

Situation Summary:

Road-related shallow rapid landslides (SR), debris torrents ([DT], including also debris flows [DF] and potentially dam break floods [DBF]) and small sporadic deep-seated landslides (SSD) in mass wasting map unit (MWMU) 1 are delivering coarse and fine sediment through steep gradient channels (GMU 4, 5 and 6) to lower gradient channels (GMU 1, 2 and 3). The primary concerns for fish habitat include:

- temporary fining of substrate from fine sediment deposition, primarily in GMU 3 and 4, reducing habitat complexity;
- temporary accumulations of fine sediment in low velocity areas reducing availability of rearing habitat in GMU 2 and lower gradient reaches of GMU 4 and 5;
- temporary and local channel aggradation and pool filling by coarse sediment, reducing habitat complexity in GMU 2, 3, and 5;
- sediment scour and fill from debris torrents resulting in reduced habitat complexity;
- turbidity during and following storm-flow events that can:
  - temporarily degrade water quality,
  - impact salmonids' ability to feed,
  - cause gill abrasion affecting respiration (extreme or chronic increases);
- removal of in-channel large woody debris by debris torrents (DT, DF, and DBF), resulting in loss of sediment storage and sorting, and removal of pool-forming steps;
- potential loss of fish populations by debris torrent scour, where those populations are isolated by barriers. Currently the existence of isolated populations is unknown in the WAU.

Note: The extent of sediment deposition would be significantly increased if the quantity of in-channel large woody debris (LWD) increases over time. Increased LWD would improve fish habitat by increasing the availability of spawning gravel, pool habitat and cover. However, if sediment sources are not controlled, storage from LWD could result in excess fine and coarse sediment storage, degrading the habitat.

Triggering Mechanisms:

The following factors lead to the generation and delivery of sediment from road-related landslides in MWMU 1:

Natural characteristics:

- Steep slopes (≥40% by the DEM), held up by relatively resistant basalts and andesites (field-measured slopes are commonly steeper).

- Concave slopes, headwalls and bedrock hollows to concentrate shallow ground water, increasing pore water pressure to destabilize slopes.
- Occurrence of large storms, routing large quantities of shallow ground water to unstable slopes.
- Clay-rich, unstable soils formed from weathered volcanics (breccias, volcaniclastics, interbedded volcanic sediments).
- In some cases, shallow ground water seeps may be reducing slope stability by increasing pore-water pressure.

Contributing management-related characteristics:

- Sidecast road and landing construction that oversteepens and overweights slopes. This accounts for 88% of the road-related landslides in this MWMU.
- Oversteepening of cutbanks on steep, unstable slopes. This accounts for 7% of the road-related landslides in this MWMU.
- Filling of road ditches by cutbank ravel or talus diverts drainage to tread and then to steep, unstable draws.
- Insufficient culvert size or blocking of culverts with woody debris, cutbank ravel or road sediment, diverting drainage to the tread and unstable fill slopes.

Maps:

Map A2 delineates the mass wasting map unit for this situation, MWMU 1. The specific areas of concern are subject to field verification, and consist of moderately steep (≥40% DEM slopes) concave slopes and headwalls.

Map A1 shows the locations of specific landslides.

Additional Comments:

Sidecast Failures:

Sixty-nine of 84 landslides (82%) identified in this MWMU are road-related. Of these, 61 (88% of 69, or 73% of 84) are associated with sidecast road or landing fill. More detailed information on these landslides is available from the landslide inventory (Appendix A).

Channel Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs. See the Channel Assessment (Appendix E) for further observations.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Management Objective:

Minimize road related failures on steep concave slopes (MWMU 1) from existing roads or landings that can deliver sediment to streams. Avoid road related failures from new roads/reconstruction and landings on steep concave slopes that can deliver sediment to streams.

PRESCRIPTION

Existing roads:

- Inventory and evaluate existing roads and landings. Review roads on a three year rotation for:
  - Evidence of potential side cast failure,
  - Cut bank stability and drainage issues,
  - Effectiveness of drainage,
  - Type of construction (standards, age, likelihood of organic debris in fills).
- When orphan roads from previous harvest are encountered, identify any issues and address when management activities are going on in the area.
- Where road evaluation indicates a potential for failure, evaluate, correct on a priority basis (imminence and resource impact) and document corrective action. Corrective actions could include:
  - Consultation with Geologist on high risk sites,
  - Pull-back sidecast,
  - Revegetating exposed slopes,
  - Cutbank stabilization,
  - Drainage controls such as relief pipes or road flaps to prevent direct drainage onto sidecast,
  - Subsequent adjacent harvest prescriptions (leave tree locations, and/or full suspension over unstable sidecast, for example).
- Ensure continued training for appropriate personnel in identifying road slope stability processes.
- Do not increase the loading on existing sidecast areas with management activities.

New Roads:

- Evaluate alternative logging systems or unit layout to avoid road and/or landing construction in high risk areas of MWMU 1. If roading is unavoidable or alternatives create a higher risk to the resource, then:
  - No sidecast road construction on concave slopes greater than 50% where failure could deliver sediment to stream,
  - Engineer drainage with culvert spacing and location to route additional water away from headwall,
  - Review new roads during the first winter after construction for potential cutbank seepage and to establish a maintenance schedule for any obvious problem areas.

Justification for Prescription:

For existing roads we will use a combination of inspection and corrective action to prevent road-related failures associated with sidecast, oversteepened cutbanks and inadequate road drainage. The Springfield Operating Area targets a three year cycle for field inspection of the area's road network, with identified high risk areas inspected more frequently. The results of the road inspection are incorporated into the prioritization of road maintenance activities.

Orphan roads are abandoned roads from previous harvest (generally more than 40 years ago), often not detectable with aerial photography. These roads are usually discovered when field personnel are out on the ground preparing for upcoming management activities. Potential problems identified with these old roads will be corrected during site preparation after harvest activities.

Continued training for operations personnel will ensure that evidence of potential failures will be recognized when they are present. This training includes personnel doing the road inspections and also people who are on the ground prior to planned management activities. The GIS maps included in the Mass Wasting module are useful for identifying where these steep, concave slopes are likely to be found in the watershed, but field verification is required to identify the specific sites. The burden for identifying the high risk areas falls on the field personnel. With training and the use of technical support when needed, we believe these areas can be identified and appropriate precautions utilized.

In most cases, evaluating alternative logging systems or unit layout will help to avoid new road construction in high risk areas of MWMU 1. The natural characteristic of the triggering mechanism is typically located mid slope, allowing for the water concentration that triggers the failures. Ridgetop to ridgetop harvest units, where feasible, would avoid mid slope road construction.

New road construction will have drainage engineered, with culvert locations and spacing, to route additional water away from headwalls. Sidecast road construction will not be allowed on slopes greater that 50%. All but one of the 29 landslides in MWMU 1 for which field slopes were measured occurred on slopes exceeding 50%. The one exception occurred on a 47% slope.

Monitoring:

The location of future failures will be mapped and given to the GIS for incorporation in the landslide inventory. If known, include date and reason for failure. This data will be evaluated at 10 year intervals to determine if the prescriptions are effective at minimizing failures from old roads and avoiding failures associated with new road construction.

Mass Wasting Resource Sensitivity A2:

Road-related failures in inner gorges, LPD-prone terrain, and very steep planar or convex slopes; moderate mass wasting hazard potential.

CAUSAL MECHANISM REPORT

Situation Summary:

Road-related shallow rapid landslides (SR), debris torrents ([DT], including also debris flows [DF] and dam break floods [DBF]) and small sporadic deep-seated landslides (SSD) in MWMU 2, 3 and 4 are delivering coarse and fine sediment through steep gradient channels (GMU 4, 5 and 6) to lower gradient channels (GMU 1, 2 and 3). The primary concerns for fish habitat include:

- temporary fining of substrate from fine sediment deposition, primarily in GMU 3 and 4, reducing habitat complexity;
- temporary accumulations of fine sediment in low velocity areas reducing availability of rearing habitat in GMU 2 and lower gradient reaches of GMU 4 and 5;
- temporary and local channel aggradation and pool filling by coarse sediment, reducing habitat complexity in GMU 2, 3, and 5;
- sediment scour and fill from debris torrents resulting in reduced habitat complexity;
- turbidity during and following storm-flow events that can:
  - temporarily degrade water quality,
  - impact salmonids' ability to feed,
  - cause gill abrasion affecting respiration (extreme or chronic increases);
- removal of in-channel large woody debris by debris torrents, resulting in loss of sediment storage and sorting, and removal of pool-forming steps;
- potential loss of fish populations by debris torrent scour, where those populations are isolated by barriers. Currently the existence of isolated populations is unknown in the WAU.

Note: The extent of sediment deposition would be significantly increased if the quantity of in-channel large woody debris (LWD) increases over time. Increased LWD would improve fish habitat by increasing the availability of spawning gravel, pool habitat and cover. However, if sediment sources are not controlled, storage from LWD could result in excess fine and coarse sediment storage, degrading the habitat.

Triggering Mechanisms:

The following factors lead to the generation and delivery of sediment from road-related landslides in MWMU 2, 3 and 4:

Natural characteristics:

- Steep slopes in MWMU 2 and 4 ($\geq$40% by the DEM in MWMU 2, $\geq$60% in MWMU 4), held up by relatively resistant basalts and andesites (field-measured slopes are commonly steeper).

- Concave slopes, headwalls and bedrock hollows in MWMU 2 and 3 to concentrate shallow ground water, increasing pore water pressure to destabilize slopes.
- Clay-rich, rapidly creeping soils in MWMU 3 that are unstable in themselves, and also increase perching of shallow groundwater, elevating pore-water pressure, further decreasing stability.
- Occurrence of large storms, routing large quantities of shallow ground water to unstable slopes.
- Close proximity and direct sediment routing to streams, especially in inner gorges (MWMU 2).

Contributing management-related characteristics:

- Sidecast road and landing construction that oversteepens and overweights slopes. This accounts for 72% of the road-related landslides in these MWMU (87% of the road-related landslides in MWMU 2 and 4).
- Oversteepening of cutbanks in clay-rich, rapidly creeping soils. This accounts for 14% of the road-related landslides in these MWMU, primarily in MWMU 3 in LPD-prone terrain (91% of the road-related landslides in MWMU 3).
- Filling of road ditches by cutbank creep or rapid failure, diverting drainage to unstable fillslopes and draws.
- Insufficient culvert size or blocking of culverts with debris, road sediment or debris torrent deposits, causing a DBF (debris torrents primarily triggered by roads upslope [see also Causal Mechanism Report Summary for Mass Wasting Resource Sensitivity A1]).

Maps:

Map A2 delineates the MWMU for this situation, 2, 3 and 4. The specific areas of concern are subject to field verification, and consist of the following:

- MWMU 2. Moderately steep (≥40% by DEM), slopes on inner gorges within the MWMU 2 polygons on Map A2.
- MWMU 3. Moderate slopes (≥30% by DEM) within the MWMU 3 polygons on Map A2.
- MWMU 4. Very Steep (≥60% by DEM) planar and convex slopes within the MWMU 4 polygons on map A2.

Map A1 shows the locations of specific landslides.

Additional Comments:

Sidecast Failures:

Fifty-eight of 181 landslides (49%) in these MWMU are road-related. Of these, 42 (72% of 58, or 23% of 181) are associated with sidecast road or landing fill. More detailed information on these landslides is available from the landslide inventory (Appendix A).

Channel Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs. See the Channel Assessment (Appendix E) for further observations.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Management Objective:

Minimize road related failures in inner gorges, LPD-prone terrain and very steep planar slopes (MWMUs 2, 3 and 4), from existing roads or landings that could deliver sediment to streams. Avoid road related failures from new roads/reconstruction and landings in these MWMUs that could deliver sediment to streams.

PRESCRIPTION

Existing Roads:

- Inventory and evaluate existing roads and landings. Review roads on a three year rotation for:
  - Evidence of potential sidecast failure,
  - Cutbank stability and drainage issues,
  - Effectiveness of drainage,
  - Type of construction (standards, age, likelihood of organic debris in fills).
- When orphan roads from previous harvest are encountered, identify any issues and address when management activities are going on in the area.
- Where road evaluation indicates a potential for failure, evaluate, correct on a priority basis (MWMU 4 [60%+ slopes] and MWMU 2 [inner gorges] are higher risk areas than MWMU 3 [LPD-prone terrain]) and document corrective action. Corrective actions could include:
  - Consultation with Geologist on high risk sites,
  - Pull-back sidecast,
  - Revegetating exposed slopes,
  - Cutbank stabilization,
  - Drainage controls such as relief pipes or road flaps to prevent direct drainage onto sidecast,
  - Subsequent adjacent harvest prescriptions (leave tree location, full suspension, no cut or partial cut areas, for example).
- Ensure continued training for appropriate personnel in identifying road slope stability processes.
  - Do not increase the loading on existing sidecast areas with management activities where failure would cause sediment delivery to stream.

New Roads:

- Evaluate alternative road placement options in high risk areas of MWMUs 2 and 4.
  - No sidecast road construction on slopes greater than 55% where a failure would deliver sediment to stream.
  - Engineer drainage with culvert spacing and location to route surface water away from sensitive areas.
- Review new road construction during the first winter after construction for potential cutbank seepage and to establish maintenance schedule for obvious problem areas.

Justification for Prescription:

For existing roads we will use a combination of inspection and corrective action to prevent road-related failures associated with sidecast, oversteepened cutbanks and inadequate road drainage. The Springfield Operating Area targets a three year cycle for field inspection of the area's road network, with identified high risk areas inspected more frequently. The results of the road inspection are incorporated into the prioritization of road maintenance activities.

Orphan roads are abandoned roads from previous harvest (generally more than 40 years ago), often not detectable with aerial photography. These roads are usually discovered when field personnel are out on the ground preparing for upcoming management activities. Potential problems identified with these old roads are typically corrected during site preparation after harvest activities.

Continued training for operations personnel will ensure that evidence of potential failures will be recognized when they are present. This training includes personnel doing the road inspections and also people who are on the ground prior to planned management activities. The GIS maps included in the Mass Wasting module are useful for identifying where these inner gorges, LPD-prone terrain and very steep planar slopes are likely to be found in the watershed, but field verification is required to identify the specific sites. The burden for identifying the high risk areas falls on the field personnel. With training and the use of technical support when needed, we believe these areas can be identified and appropriate precautions utilized.

In most cases, evaluating alternative logging systems or unit layout will help to avoid new road construction in high risk areas of MWMU 2 and 4.

New road construction will have drainage engineered, with culvert locations and spacing, to route additional water away from sensitive areas. Sidecast road construction will not be allowed on slopes greater that 55%. Of the 14 landslides in MWMU 2 and 4 for which field slopes were measured, 12 occurred on slopes of 55% or greater. The two exceptions are a dam-break flood, which occurred in the channel itself as opposed to on the slope, and a shallow rapid landslide, which initiated on a 40% slope.

Typically, roads are built in the summer when weather conditions may not show how the road has impacted drainage. Reviewing new roads the first winter after construction should show any areas that may need additional relief culverts to route cutbank seepage onto the forest floor.

Monitoring:

The location of future failures will be mapped and given to the GIS for incorporation in the landslide inventory. If known, include date and reason for failure. This data will be evaluated at 10 year intervals to determine if the prescriptions are effective at minimizing failures from old roads and avoiding failures associated with new road construction.

Mass Wasting Resource Sensitivity A3:

Non-road-related failures in steep, concave slopes and inner gorges; moderate mass wasting hazard potential.

CAUSAL MECHANISM REPORT

Situation Summary:

Shallow rapid landslides (SR), debris flows (DF), debris torrents (DT) and small sporadic deep-seated landslides (SSD) in MWMU 1 and 2 are delivering coarse and fine sediment through steep gradient channels (GMU 4, 5 and 6) to lower gradient channels (GMU 1, 2, and 3). The primary concerns for fish habitat include:

- temporary fining of substrate from fine sediment deposition, primarily in GMU 3 and 4, reducing habitat complexity;
- temporary accumulations of fine sediment in low velocity areas reducing availability of rearing habitat in GMU 2 and lower gradient reaches of GMU 4 and 5;
- temporary and local channel aggradation and pool filling by coarse sediment, reducing habitat complexity in GMU 2, 3, and 5;
- sediment scour and fill from debris torrents resulting in reduced habitat complexity;
- turbidity during and following storm-flow events that can:
  - temporarily degrade water quality,
  - impact salmonids' ability to feed,
  - cause gill abrasion affecting respiration (extreme or chronic increases);
- removal of in-channel large woody debris by debris torrents (DT, DF, and DBF), resulting in loss of sediment storage and sorting, and removal of pool-forming steps;
- potential loss of fish populations by debris torrent scour, where those populations are isolated by barriers. Currently the existence of isolated populations is unknown in the WAU.

Note: The extent of sediment deposition would be significantly increased if the quantity of in-channel large woody debris (LWD) increases over time. Increased LWD would improve fish habitat by increasing the availability of spawning gravel, pool habitat and cover. However, if sediment sources are not controlled, storage from LWD could result in excess fine and coarse sediment storage, degrading the habitat.

Triggering Mechanisms:

The following factors lead to the generation and delivery of sediment from non-road-related landslides in MWMU 1 and 2:

Natural characteristics:

- Steep slopes (≥40% by the DEM), held up by relatively resistant basalts and andesites (field-measured slopes are commonly steeper).
- Concave slopes, headwalls and bedrock hollows to concentrate shallow ground water, increasing pore water pressure to destabilize slopes.
- Occurrence of large storms, routing large quantities of shallow ground water to unstable slopes.
- Clay-rich, unstable soils formed from weathered volcanics (breccias, volcaniclastics, interbedded volcanic sediments).
- In some cases, shallow ground water seeps may be reducing slope stability by increasing pore-water pressure.
- Close proximity and direct sediment routing to streams, especially in inner gorges (MWMU 2).

Contributing management-related characteristics:

Eighteen out of 23 non-road-related landslides (78%), for which applicable stand age data is available within these MWMU, probably occurred within 20 years of harvest. This suggests that in most cases the slope stability was reduced by harvest, possibly associated with:

- reduction in root strength (Burroughs and Thomas 1977, Krogstad 1996, Ziemer 1981), and/or
- increases in shallow subsurface pore-water pressure following removal of vegetation during harvest.

Maps:

Map A2 delineates the mass wasting map units for this situation, MWMU 1 and 2. The specific areas of concern are subject to field verification, and consist of the following:

- MWMU 1. Moderately steep (>40% field-observed slopes) concave slopes and headwalls within the MWMU 1 polygons on Map A2.
- MWMU 2. Moderately steep (≥40% by DEM), slopes on inner gorges within the MWMU 2 polygons on Map A2.

Map A1 shows the locations of specific landslides.

Additional Comments:

In-unit Failures:

The following table lists the non-road-related landslides associated with MWMU 1 and 2 for which applicable stand age data is available. Large deep-seated landslides have not been listed, because of greater ambiguity in their initiation date.

Table CMA1 Non road-related landslides associated with MWMU 1 and 2 for which applicable stand age data is available.

Landslide Number	Slide Type	Slope Type	Position	DEM Slope (%)	Estimated Years Since Harvest	Estimated Delivered Volume (m^3)
135	SR	Planar	Ridge	85	33	6,552
105	SSD	Concave	Stream Adjacent	25	25	5,879
123	SR	Concave	Ridge	55	12	5,205
96	DF	Concave	Midslope	65	8	1,834
75	SR	Concave	Stream Adjacent	65	28	1,808
127	SR	Concave	Midslope	75	7	1,301
87	SR	Concave	Midslope	45	16	1,130
98	DF	Concave	Midslope	55	8	459
118	DF	Concave	Midslope	85	6	306
114	DF	Concave	Midslope	65	12	306
46	SR	Concave	Midslope	85	12	228
76	DT	Concave	Midslope	85	28	226
77	DT	Concave	Midslope	75	25	226
97	DF	Concave	Midslope	45	8	153
221	LPD	Convex	Midslope	65	7	55
200	SR	Concave	Stream Adjacent	45	7	32
217	DF	Planar	Midslope	55	7	17
40	SR	Concave	Midslope	35	2	0
258	SR	Concave	Midslope	85	3	0
204	SR	Planar	Midslope	55	1	0
45	SR	Concave	Midslope	85	5	0
44	SR	Concave	Midslope	85	5	0
101	SR	Concave	Midslope	75	5	0

Channel Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs. See the Channel Assessment (Appendix E) for further observations

Location GMU	Example Stream Segments	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Management Objective:

Minimize in-unit landslides and their adverse effects due to management related activities on steep concave slopes and inner gorges (MWMUs 1 and 2) that could deliver sediment to streams.

PRESCRIPTION

- Ensure continued training for appropriate field personnel in identifying topographical/ geological features that accompany areas of high risk. Utilize a geologist or qualified slope stability specialist when risk is indeterminate.
- Consider alternative harvest plans when operating in high risk areas. These may include:
  - Partial cut, selective cut or no cut areas,
  - Redesigning harvest boundaries,
  - Suspension logging,
  - Falling and yarding away from unstable areas,
  - Longer greenup timeframes between adjacent harvest units.,
  - Loading leave trees in downslope draws from likely landslide areas to help arrest a failure and/or provide LWD to channel if a failure does occur.
- Use harvest and forest management techniques that avoid concentrating flow in MWMU 1. For example:
  - Yard away from headwall areas.
  - Downhill skyline corridors should not use a fan pattern when that pattern will result in flow concentration to steep concave slopes.
  - Evaluate placing leave trees in unstable areas if the site is suitable (i.e., wind-firm, safe, operationally feasible).
  - Evaluate retaining understory vegetation, particularly big-leaf maple or alder. The trade off for this may be the difficulty of establishing conifer regeneration, which may supply more root strength stability over the long-term.
- Evaluate the adequacy of the riparian area protection plan to protect the identified inner-gorge area to the slope break. In areas that current practices do not adequately protect the inner-gorge area to the slope break, adjust the unit layout and harvest plan considering:
  - Use leave tree placement in riparian areas to provide additional root strength in unstable inner-gorge areas. Include an evaluation for wind firmness when planning leave tree placement.
  - Enhanced regeneration (i.e., higher density, older stock) of sensitive inner-gorge areas after harvesting to enhance root strength over time.
  - Use harvesting methods that do not disturb the identified inner-gorge areas.
  - Leave additional trees a minimum of 20 feet beyond the slope break to protect unstable areas.
- Adapt management prescriptions for Mass Wasting in response to any newly acquired knowledge/understanding of triggering mechanisms.

Justification for Prescription:

Training provided to field personnel will improve their ability to recognize and evaluate areas vulnerable to disturbance and prone to failure. This training also gives them the ability to know when conditions or planned management activities warrant the use of geotechnical support. Features which are typical of steep concave slopes or sites prone to inner gorge failures can be identified as units are being laid out for harvesting activities. The field engineer can use these features and evidence of current or past failure to evaluate the potential for future failure. As we gather more data and refine the triggering mechanisms, we will continue to incorporate this learning into our management activities.

Grouping leave trees downslope (in draws) from potential slide areas will have several functions. If a slide occurs, these trees will help to dissipate energy. If the slide has sufficient force to uproot the trees, this then becomes a large woody debris contribution to the streambed and helps minimize the distance the slide moves down channel. (Note that in unmanaged watersheds this sequence is many times a contributor of LWD to the stream.) Grouping leave trees in or adjacent to riparian trees is also preferred operationally.

Techniques that can result in concentrating flow will be avoided in areas of suspected risk. These areas may be especially susceptible to artificial concentrations of surface or sub-surface run-off.

Current riparian zone protection may encompass the identified inner gorge areas. If the current riparian protection is not adequate, additional leave trees to protect the slope break may be needed since the break itself is where many failures are initiated.

Harvest unit layout must be evaluated with the sensitive high risk areas in mind. Windthrow is a risk, depending on the location of leave trees in relation to terrain and other surrounding timber. In the case of the inner gorge areas, windthrown trees can result in soil disturbance and create an additional sediment source to the stream. The field engineers must use their experience to weigh the trade-offs regarding leave tree selection. Harvesting methods and layout can be adapted to avoid soil disturbance impacts to these areas.

Monitoring:

The location of future failures will be mapped and given to the GIS for incorporation in the landslide inventory. If known, include date and reason for failure. This data will be evaluated at 10 year intervals to determine if the prescriptions are effective at minimizing failures from old roads and avoiding failures associated with new road construction.

Surface Erosion Resource Sensitivity B1:

Dirt roads / abandoned roads.

CAUSAL MECHANISM REPORT

Situation Summary:

Surface erosion from dirt roads has the potential to deliver significant fines to the stream system. Frequently dirt roads are vegetated but subsurface flow and runoff is diverted to the compacted tread, causing concentrated flows to create gullies. Deliveries to the stream system may occur, causing localized pool-filling and increased turbidity to downstream segments.

Fine sediment can deposit in and affect smaller, lower gradient stream channels where stream power is low relative to input volumes and less able to flush sediment deposits. In addition, localized deposits of sediment in reaches with spawning gravels have the potential for impacts in larger tributary channels where anadromous fish spawn. Resident fish and rearing juvenile anadromous fish are affected if pool filling occurs. Impacts from increased turbidity are present in all reaches regardless of stream size.

- One sensitivity in the fish-bearing segments is localized deposition of sand sized fine sediment which could potentially contaminate spawning gravels of salmonids and reduce rearing areas by filling pools. The following areas would be sensitive if inputs are large: GMUs 1 and 2 for reducing habitat complexity and possible intrusion into spawning gravels; GMU 2 and lower gradient reaches of 4 and 5 for rearing habitat.
- A second sensitivity is turbidity during storm events. Depending on duration and severity, high turbidity conditions can:
  - potentially degrade water quality,
  - impact salmonids' ability to feed,
  - under extreme levels cause gill abrasion affecting respiration, particularly of juvenile fish.

Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Triggering Mechanisms:

- Old dirt roads dating from the first timber harvesting done in the watershed are still evident on the landscape. Those roads built in areas with shallow A horizons and/or impeded internal drainage are prone to surface erosion. Subsurface flow and runoff is diverted to the compacted tread, where erosion causes gullies to develop.
- Frequently after roads are abandoned there is no access for maintenance vehicles and drainage problems easily develop. Road and ditch drainage can concentrate flows and be a source for erosion. Sidecast on roads and landings that have not been pulled back can fail. Exposed soils erode easily off cutslopes and the road running surface.
- When harvesting on gentle ground with ground-based equipment, dirt roads are constructed into a unit. After the harvest is completed, if the road is not closed, recreational vehicles can potentially gain access to the road and compact the surface. During rainy weather, long tread flow-paths develop on these roads which do not have relief drainage. Frequently subsurface flows are intercepted by the tread flow-path and runoff concentrates in the tread, eroding the road surface and delivering fine sediment to drainage systems.
- Recently built dirt roads are potentially very high fine sediment deliverers until the tread surface and cutslope becomes armored and/or ditchouts are used to divert flow. If roads are driven on, armoring is removed.

Example Sites:

Road #
Old dirt roads off the 100 Road in the upper headwaters of the Cedar sub-basin—gullies.
U.S.F.S. 427--abandoned road fill failure.
Harvest unit off the 100 Road at the 130 Road in Cedar sub-basin--long-tread flow path.

Location:

Refer to Map CMB1.

Additional Comments:

- When roads are abandoned (obliterated) the road should not require any future maintenance. Maintenance guidelines should refer to active roads. Road abandonment guidelines should focus on the road drainage (e.g., ditches, culverts, crown, dips, waterbars, insloping, outsloping) and the protection of public resources. Blockage and closure of the road can be done using tank traps, rip rap, root wads, logs or slash. Road and ditch drainage should be routed to create the most natural and/or non-erosive drainage pattern. This may require removal of culverts since drainage structures not removed will eventually fail. Non-driveable waterbars and dips can be constructed to disperse runoff and minimize erosion. Sidecast on roads and landings that have a potential of failing should be pulled back. Exposed soils should be revegetated at the appropriate time of the year. The running surface of the forest road should be ripped to create a softer seed bed for germination of vegetation.

Photographs:

PHOTO CMB1. Photo of a gully in the tread of an abandoned road in the headwaters of Cedar Creek/Hills Creek drainage.

Management Objective:

Minimize sediment delivery to streams from dirt roads / abandoned roads.

PRESCRIPTION

Dirt Roads:

- Cultivate temporary logging roads after use (put to bed).
- Maintain roads to Weyerhaeuser Road Maintenance Manual guidelines (see Prescription Documents section).
- Restrict general access to dirt roads on Weyerhaeuser ownership.
  - Logging roads that will be reused will be blocked and waterbarred to restrict access during wet weather.

- Newly constructed roads that winter over before being rocked will be stabilized using practices outlined in the Weyerhaeuser Road Maintenance Manual (see Prescription Documents section).
- Maintain drainage integrity on closed dirt roads by continuing to educate all users to ensure dirt roads will not be used during periods of wet weather when damage would occur. This may include specific language in contracts or signs at barriers blocking access to the road.

Abandoned or Orphan Roads:

- When orphan roads from previous harvest are encountered, identify any contributing or potentially contributing sediment issues and address when management activities are going on in the area.
- When abandoning a road, follow Oregon Department of Forestry standards to meet the Oregon Forest Practices Act.

Justification for Prescriptions:

The *Willamette Timberlands Road Maintenance Manual* (last updated January 1997) was designed by a cross-functional group of Weyerhaeuser operating personnel specifically to improve maintenance practices. Objectives included reducing erosion and minimizing sediment delivery to stream channels.

The *Manual* includes practices drawn from prescriptions specified in the four previous watershed analyses conducted on our land (Upper Mohawk, Lower McKenzie southside, Lower McKenzie northside and the Upper Siuslaw Watersheds), as well as from adaptive trials conducted in the Willamette Region. We feel these practices generally minimize sediment delivery and they will be actively updated as we try new procedures and evaluate effectiveness.

Traffic on dirt roads in wet weather creates ruts that channel water, cause erosion, and allow sediment delivery to streams. Most erosion control efforts will be ineffective if traffic is not limited. We will manage this by putting to bed and blocking roads not needed for access, and closing with gates or other means roads that must be retained for access.

We currently have language in all of our contracts regarding dirt roads. Hunters are informed of our policies regarding dirt roads. No matter what is done, there is the possibility of vandalism and damage occurring from opening our gates during hunting season. Our intent is to educate the people who may be visiting our lands on the importance of maintaining the integrity of these roads and their drainage.

Orphan roads are abandoned roads from previous harvest (generally more than 40 years ago), often not detectable with aerial photography. These roads are usually discovered when field personnel are on the ground preparing for upcoming management activities. These old roads are typically ripped, pulled and planted during site preparation after harvest activities.

Monitoring:

N/A

Surface Erosion Resource Sensitivity B2:

Long ditch infeed lengths.

CAUSAL MECHANISM REPORT

Situation Summary:

Long ditch infeed lengths on logging roads with few relief drains are delivering fine sediment directly and indirectly to fish-bearing streams. Many roads do not have relief drains, ditchouts or sediment catch basins to capture runoff and/or redirect flow to filter through the forest floor. This is primarily a situation which results in increased turbidity throughout the WAU and localized pool filling in fish-bearing waters.

Fine sediment can deposit in and affect smaller, lower gradient stream channels where stream power is low relative to input volumes and less able to flush sediment deposits. However, localized deposits of sediment in reaches with spawning gravels have the potential for impacts in larger tributary channels where anadromous fish spawn. Resident fish and rearing juvenile anadromous fish are affected if pool filling occurs. Impacts from increased turbidity are present in all reaches regardless of stream size.

- One sensitivity in the fish-bearing segments is localized deposition of sand sized fine sediment which could potentially contaminate spawning gravels of salmonids and reduce rearing areas by filling pools. The following areas would be sensitive if inputs are large: GMUs 1 and 2 for reducing habitat complexity and possible intrusion into spawning gravels; GMU 2 and lower gradient reaches of 4 and 5 for rearing habitat.
- A second sensitivity is turbidity during storm events. Depending on duration and severity, high turbidity conditions can:
  - potentially degrade water quality,
  - impact salmonids' ability to feed,
  - under extreme levels cause gill abrasion affecting respiration, particularly of juvenile fish.

Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Triggering Mechanisms:

The following factors lead to the generation and delivery of potentially large quantities of sediment from long infeed lengths:

- Because of the many miles of midslope road with light haul traffic, these roads have a potential for high cumulative sediment yield to the stream system. More frequent drainage relief is especially important on midslope roads with long infeed length ditchlines draining directly to stream crossings or lower elevation road ditchlines.
- Much of the runoff and fine sediment generated on the road tread and ditchline is delivered directly to a live stream channel by the road ditch. Many roads do not have adequate drainage along ditchlines since few relief drainage structures have been installed. More relief drains, ditchouts or sediment catch basins would capture runoff and/or direct flow to filter through the forest floor.
- Tread runoff generally delivers half to the fillslope and half to the cutslope with crowned or insloped and outsloped roads. Because of the lack of a crowned surface on the tread of the road, the tread is delivering much of its runoff from the tread to the ditchline.
- Steep grades with long-infeed lengths cause ditchlines to downcut. Sediment deposited in the ditchline easily erodes with rain storms and delivers fine sediment to the stream system.
- Long ditch infeed lengths can concentrate flows which increase the potential for cutslope slump block failures as the toe of the cutslope is cut away by ditchline flow.
- Sparsely vegetated cutslopes generate large volumes of fine sediment in localized areas. This is particularly evident in large persistent deep-seated landslide areas and regions of well weathered, deep clay soils and clay substrates. Concentrated flows of ditchline water from long infeed lengths pick up enough velocity to downcut the ditchline and scour the ditchline of vegetation.
- Heavy traffic, where present, greatly increases the quantity of fine sediment that is potentially eroded from the tread, enters the ditchline and delivers to the stream.

Example Sites:

The following list of roads and road segments provides examples of this road situation from the road inventory.

Road #	Segment #	Length Miles	Fine Sediment Yield Tonnes/Year Light Haul
LFC 7080	943	0.25	10
LFC 6000	733	0.39	6
HCR 370	106	0.18	6
LFC 7000	802	0.58	5

Prioritization:

1. Long ditch infeed lengths on steeper gradient roads delivering directly to fish-bearing waters.
   - Long ditch infeed lengths on steep heavy haul road segments (mainline roads) delivering directly to fish-bearing waters.
   - Long ditch infeed lengths on steep moderate haul road segments (primary/secondary roads) delivering directly to fish-bearing waters
   - Long ditch infeed lengths on steep light haul road segments (spur roads) delivering directly to fish-bearing waters.
2. Long ditch infeed lengths on all other road segments delivering to live stream drainages.

Additional Comments:

Road drainage should include consideration of the following factors:

1. The type of drainage (i.e., fish passage).
2. The adequate capacity of culverts (culvert sizing).
3. The right quantity of culverts to reduce the concentration of flow.
4. The correct locations of cross drains to divert flow to a forest floor.
5. Road surface waters from the tread should be prevented from flowing onto unprotected fills or into flowing waters using inslope or outslope surfaces.

Photographs:

PHOTO CMB2. Flow diverted into ditchline with a long infeed length along Hills Creek mainline.

Management Objective:

Minimize fine sediment delivery to streams resulting from long ditch in-feed lengths on forest roads.

PRESCRIPTION

New Roads

- Follow Weyerhaeuser Road Maintenance Manual guidelines for culvert placement on new road construction (see Prescription Documents section).

Existing Roads

- Prioritize areas for road drainage improvements considering:
  - Upcoming winter hauling activities,
  - Subsurface flow in LPD-prone terrain,
  - Known road segments potentially delivering sediment to streams,
  - Road erosion assessment from watershed road inventory.
- High priority road segments will be upgraded as resources permit. Upgrading may include:
  - Installing additional culverts for cross drainage and spacing,
  - Targeting ditch relief 150 to 200 feet prior to stream crossing when topography allows,
  - Road crowning,
  - Ditches will be pulled only when necessary and will be reseeded afterward when appropriate,
  - Cutslope revegetation efforts will target the segment between the last ditch relief culvert and the stream crossing.
- Maintain forest roads following the guidelines outlined in the Weyerhaeuser Road Maintenance Manual (see Prescription Documents section).

Justification for Prescription:

The *Willamette Timberlands Road Maintenance Manual* (last updated January 1997) was designed by a cross-functional group of Weyerhaeuser operating personnel specifically to improve maintenance practices. Objectives included reducing erosion and minimizing sediment delivery to stream channels.

The *Manual* includes practices drawn from prescriptions specified in the four previous watershed analyses conducted on our land (Upper Mohawk, Lower McKenzie southside, Lower McKenzie northside and the Upper Siuslaw Watershed), as well as from adaptive trials conducted in the Willamette Region. We feel these practices generally minimize sediment delivery and they will be actively updated as we try new procedures and evaluate effectiveness.

The *Manual* includes current road construction standards which outline drainage requirements, including maximum relief culvert spacing by road gradient classes and designing culverts for a 50-year flood with a minimum 24" culvert in definite draws. The *Manual* recognizes the impact soil types have on sediment generation. Targeting 150 feet for a relief drain before crossing a live stream will divert the sediment out onto the forest floor, keeping it out of the channel.

The level of hauling activity is a major factor in sediment generation from forestry roads. We will identify roads with upcoming winter haul activity and place a priority on them for drainage upgrading.

Monitoring:

N/A

Surface Erosion Resource Sensitivity B3:

Stream adjacent roads.

CAUSAL MECHANISM REPORT

Situation Summary:

Erosion from stream adjacent road segments is delivering significant fine sediment to the stream channels. When the stream adjacent road is a mainline with heavy haul traffic or a secondary road with moderate traffic, fine sediment is primarily generated from the tread. Cutslopes may also deliver fine sediment, but fillslopes are generally well vegetated and filter fine sediment through the forest floor. Stream adjacent mainlines with low gradients and long infeed lengths may pond water and allow some fine grained particles to settle out.

Fine sediment can deposit in and affect smaller, lower gradient stream channels where stream power is low relative to input volumes and less able to flush sediment deposits. However, localized deposits of sediment in reaches with spawning gravels have the potential for impacts in larger tributary channels where anadromous fish spawn. Resident fish and rearing juvenile anadromous fish are affected if pool filling occurs. Impacts from increased turbidity are present in all reaches regardless of stream size.

- One sensitivity in the fish-bearing segments is localized deposition of sand sized fine sediment which could potentially contaminate spawning gravels of salmonids and reduce rearing areas by filling pools. The following areas would be sensitive if inputs are large: GMUs 1 and 2 for reducing habitat complexity and possible intrusion into spawning gravels; GMU 2 and lower gradient reaches of 4 and 5 for rearing habitat.
- A second sensitivity is turbidity during storm events. Depending on duration and severity, high turbidity conditions can:
  - potentially degrade water quality,
  - impact salmonids' ability to feed,
  - under extreme levels cause gill abrasion affecting respiration, particularly of juvenile fish.

Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Triggering Mechanisms:

The following factors lead to the generation and delivery of fine sediment from stream adjacent roads:

- The close proximity of roads to a stream channel creates situations where road drainage flows into the channel either directly or indirectly. This is especially true where relief drainage structures have not been installed for long distances along the road to route road runoff to wider areas of forest floor between the road and the channel.
- Because of the lack of available land between the road and the stream for receiving runoff, even if relief drainages are available to route runoff away from the channel, fine sediment is not able to filter through the forest floor. Extra measures should be taken to route runoff away from the stream onto a forest floor or land surface, which may filter the fine sediment, and, where feasible, to install sediment catch basins to filter sediments.
- Some ditchlines are periodically cleaned and left unvegetated. The lack of vegetation allows erosion of the ditchline and transport of road sediment.
- Heavy traffic greatly increases the quantity of sediment eroded from the tread of the road. In many cases erosion of the road tread occurs from ruts which have developed from truck tires during haul.
- Where roads cross fish-bearing stream channels, most, if not all, runoff and fine sediment generated on the road prism is delivered directly to the stream channel. Long tread flow-paths and long infeed lengths along the ditchline generate and deliver fines from the cutslope and tread.
- In some situations grades frequently drain from both directions of the road to a live stream crossing, causing fine sediment to be delivered directly into fish-bearing waters.
- Fillslopes frequently mimic the high delivery conditions of ditchlines because a significant road running length is close to the stream and drainage enters the fillslope area and delivers directly to the stream channel.
- Fill material that is placed stream adjacent along forest roads is bare and unvegetated and easily erodes with heavy rainfall. Removed fill and end haul material should be placed in a stable location that will not erode and deliver to the stream network.

Example Sites:

During heavy haul, road segments in close proximity to streams in the WAU are delivering some of the higher volumes of sediment to the stream system.

Road #	Segment #	Length Miles	Fine Sediment Yield Tonnes/Year Heavy Haul
LFC M/L	507	1.03	112
LFC M/L	405	0.44	47
LFC M/L	494	0.30	39
LFC M/L	401	0.20	25
LFC M/L	404	0.22	24
LFC M/L	478	0.17	19

Prioritization:

1. Heavy haul on stream adjacent roads on road crossing segments at fish bearing streams.
2. Heavy haul on stream adjacent roads on all other segments.
3. Moderate and light haul on stream adjacent roads on road crossing segments at fish bearing streams.
4. Moderate and light haul on stream adjacent roads on all other segments.

Location:

Refer to Map CMB1.

Photographs:

PHOTO CMB3. Photo taken during winter of 1996 along the Little Fall Creek Mainline Road. The road was under a heavy haul traffic situation.

Management Objective:

Minimize sediment delivery from streamside roads.

PRESCRIPTION

Prioritize areas for resource allocations based on volume of sediment delivery projected to make it to the stream. Recognize that the areas of emphasis will change based on the amount of activity the different road segments are supporting from various management activities.

- Where economically practicable, use high quality rock on streamside roads. Where high quality rock is not available, use other management techniques to minimize sediment generated (i.e., seasonal activities road maintenance techniques).

- Consider installing sediment catch basin, ditchline diversions and/or cross drains prior to live stream crossings to filter sediments.
- Use soil stabilization techniques such as grass seeding, mulching and matting on unvegetated cut slopes between the last ditch culvert and the stream crossing where there is evidence of siltation.
- Use methods to divert travel surface run-off such as diversion flaps, rolling dips, crowning and road sloping, water barring, regular road maintenance and berms.
- Avoid regular road maintenance activities during periods of heavy rainfall.
- Maintain established vegetation in ditch lines and at the bottom of cut slopes where it does not interfere with normal ditch function.
- Consider adding a lift of rock (2"-6") to selected streamside road segments prior to active hauling.
- Consider use of geotextile barriers to control sediment delivery from streamside roads.
- Maintain roads to *Weyerhaeuser Road Maintenance Manual* guidelines with special emphasis on areas with potential for delivery (see Prescription Documents section).
- Restrict access to forestry and dirt roads where appropriate to minimize delivery of sediments to streams and meet current ODF Standards.
- Maintain ongoing training for company and contract road maintenance operators as needed to ensure compliance with road maintenance expectations.
- Avoid placement of waste piles from end haul construction along stream-adjacent roads where there is potential of delivering sediment to the stream.
- Vegetate existing waste piles along stream-adjacent roads that can deliver sediment to the stream.

Justification for Prescriptions:

The level of hauling activity determines the quantity of sediment eroded from the tread of the road. Identifying roads with upcoming hauling activity and prioritizing these road segments for improvement using the criteria outlined in this causal mechanism will allow us to get the most benefit for the resources allocated.

Streamside roads have a higher probability of delivering sediment to the stream because of their proximity and the lack of permeable forest floor before reaching the channel. The prescriptions for this causal mechanism list a host of possible activities to minimize sediment delivery to the stream. The land managers have many options to choose from to cover the various situations that may be encountered. Some will work better in specific areas than others.

An additional lift of rock along streamside roads can be effective in reducing the amount of fines that can be pumped to the road surface and carried to the stream. This may be very effective where there is a limited window of heavy traffic and a definite streamside sediment problem. Using high quality rock will prevent the surface from breaking down with use and introducing additional sediment to the tread.

Monitoring:

N/A

Surface Erosion Resource Sensitivity B4:

Diversion of subsurface flow of water into forest road ditchline.

CAUSAL MECHANISM REPORT

Situation Summary:

Near-surface ground water is intercepted by the road prism and is being concentrated in ditchlines. This increases the potential for fine sediment to be introduced to the channel from the cutslope and tread of the road. This is primarily a situation which results in increased turbidity throughout the WAU and localized pool filling in fish-bearing waters.

Fine sediment can deposit in and affect smaller, lower gradient stream channels where stream power is low relative to input volumes and less able to flush sediment deposits. However, localized deposits of sediment in reaches with spawning gravels have the potential for impacts in larger tributary channels where anadromous fish spawn. Resident fish and rearing juvenile anadromous fish are affected if pool filling occurs. Impacts from increased turbidity are present in all reaches regardless of stream size.

- One sensitivity in the fish-bearing segments is localized deposition of sand sized fine sediment which could potentially contaminate spawning gravels of salmonids and reduce rearing areas by filling pools. The following areas would be sensitive if inputs are large: GMUs 1 and 2 for reducing habitat complexity and possible intrusion into spawning gravels; GMU 2 and lower gradient reaches of 4 and 5 for rearing habitat.
- A second sensitivity is turbidity during storm events. Depending on duration and severity, high turbidity conditions can:
  - potentially degrade water quality,
  - impact salmonids' ability to feed,
  - under extreme levels cause gill abrasion affecting respiration, particularly of juvenile fish.

Observations:

The following table lists several observations of fine sediment in channels. Observations of fine sediment in the channel are the result of both natural background inputs and management-related inputs.

Location GMU	Affected Fish	Observations
All GMUs	All anadromous and resident fish	• Turbidity observed during and following high flow events
GMUs 2,4 and 5	Anadromous fish in GMUs 2 and 4 and resident fish in all	• Storage of fine sediment at channel margins • Fine sediment accumulation in backwater areas • Some filling of gravel and cobble interstices

Triggering Mechanism:

The following factors lead to the generation and delivery of fine sediment from ditchlines that intercept and concentrate flow from subsurface flows:

- In areas where the geologic parent materials have weathered to deep clay soils, subsurface flows are shallow and are easily intercepted by road ditchlines.
- When roads are built with long ditch infeed lengths, flows of water are diverted from springs and seeps, and concentrate in the ditchline during runoff. The erosive power of the water in the ditchline has the potential to downcut the ditch, producing fine sediment which may deliver to live streams.
- Sparsely vegetated cutslopes ravel into the ditchline during the dry season and erode through sheetwash during heavy runoff. Cutslopes with no vegetation deliver larger volumes of fine sediment to stream systems.

Example Sites:

The following list of roads and road segments provides examples of this road situation from the road inventory.

Road #	Segment #	Length Miles	Fine Sediment Yield Tonnes/Year Light Haul
18-1-73 BLM	Cedar Creek	--	--
HCR 100	326	0.10	0.1
HCR 100	331	0.13	3.0
HCR 353	244	0.03	1.5
LFC 3100	625	0.10	5.5

Prioritization:

1. Those road segments found within large persistent deep-seated landslide areas within areas of deep clay soils.
2. Other road segments identified as having drainage diverted to the ditchline with a long ditch infeed length.

Management Objective:

Minimize the effects of the interception of subsurface flow in deeply weathered clays which erodes ditchlines and delivers fine sediment to streams.

PRESCRIPTION

In areas where these conditions are known to exist:

- Where possible, avoid building new roads

In areas where there are existing roads or new construction is unavoidable:

- Slow drainage in ditch to avoid down cutting. Consider:
  - Putting non-erodible material in ditch to slow the flow,
  - Installing culverts for cross drainage,
  - Vegetating cut slope where possible.
- New construction in LPD-prone terrain will be reviewed during the first winter after construction for potential cut bank seepage and to establish maintenance schedule for any obvious problem areas.
- Utilize flatter grades and minimize cuts when building new road.

Justification for Prescriptions:

The prescriptions written are a mix of prevention and mitigation. While the field engineers can often identify areas likely to have subsurface drainage, (hummocky ground, light brown or gray soil colors and by the vegetation present), these areas can not always be identified in advance, especially seeps and springs, or totally avoided with new road construction.

Typically, roads are built in the summer when weather conditions may not show how the road has impacted drainage. Reviewing new roads the first winter after construction should show any areas that may need additional relief culverts to route cutbank seepage onto the forest floor.

Monitoring:

N/A

Hydrology Resource Sensitivity C1:

Potential increases in peak flows for small headwater tributaries in the rain-on-snow (ROS) zone.

CAUSAL MECHANISM REPORT

Situation Summary:

Conversion of upper Hills Creek, Norton Creek, Sturdy Creek, Walker Point and Upper Little Fall Creek subbasins to immature and/or intermediate hydrologic maturity may increase ROS peak flows by more than 20%. A peak flow increase of 20% or more has the potential to increase the frequency of scour in spawning areas.

Triggering mechanism:

The following factors lead to the generation of increased peak flows in the WAU:

- Timber harvest at a rate that converts small headwater tributary subbasins in the rain-on-snow zone to a hydrologically immature and/or intermediate canopy cover. This may lead to increased rain-on-snow peak flows.
- Extensive forest fires that rapidly convert small headwater tributary subbasins to hydrologically immature and/or intermediate canopies can also potentially cause an increase in rain-on-snow generated peak flows.

Additional Comments:

See Map C2 in Hydrologic Assessment Appendix for location of ROS zones and Table CMC1 for a summary of hydrologic maturity by subbasin and potential peak flow increases for a 2-year event.

TABLE CMC1. Hydrologic maturity, and potential peak flow increases (percent) for subbasins within the WAU.

Subbasin	Percent of subbasin in hydrologic maturity category			Potential increases in 2-year event (percent)	
	Immature	Intermediate	Mature	Current stand condition	Completely Immature
Hills Creek	25.1	6.3	68.6	4.4	22.8
Lower Little Fall Creek	10.5	26.3	63.2	2.2	16.1
Norton Creek	3.0	12.5	84.4	1.8	24.4
Sturdy	4.9	4.7	90.4	1.9	25.4
Walker Point	0.5	11.6	87.7	1.9	25.3
Upper Little Fall Creek	1.1	3.6	95.2	0.7	25.3

Management Objective:

Avoid management activities that would increase peak flows by more than 20% in the subbasins cited in this causal mechanism.

PRESCRIPTION

- Continue to manage our lands and conduct our harvest scheduling under the direction of Weyerhaeuser Forestry resource strategies. These strategies include:
  - harvesting at sustainable rates over the long term,
  - developing and implementing processes to assess the impact of our forest practices on water quality and fish habitat, and adapting our practices accordingly,
  - continuously improving management practices in streamside areas,
  - implementing landscape planning for wildlife.

- Revisit the hydrologic maturity on the subbasins within the watershed every 5 years (sooner if a natural event warrants). Use the Hydrologic Assessment model with the projected harvest patterns to monitor the hydrologic maturity categories at several future time periods.

Justification for Prescriptions:

The Forest Practices Act regulates clearcut size and greenup timing for harvesting on private lands. Weyerhaeuser Forestry resource strategies also add protections from harvesting at an accelerated rate in these identified subbasins.

Periodically rerunning the hydrologic model using our latest harvest projections and reviewing the stand conditions for several future time periods will allow us to monitor the trends for the subbasins and identify any areas that may require revised harvest planning to ensure against peak flow increases from management activities which might be damaging to salmonid spawning beds.

Monitoring:

Review hydrologic maturity assessment when it is repeated. If this assessment surfaces any concerns, reopen the prescription.

Riparian Resource Sensitivity D1:

Current high large woody debris recruitment potential (dense large-diameter conifer and mixed stands).

CAUSAL MECHANISM REPORT

Situation Summary:

Medium and large-diameter conifer and mixed conifer and hardwood riparian stands are currently of a size sufficient to contribute large woody debris (LWD) to channels. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, in-channel wood of a size and quantity to affect channel morphology and therefore physical fish habitat may be limited.

Triggering mechanism:

Currently, dense stands of large-diameter conifer and mixed conifer and hardwood riparian areas are considered to have high LWD recruitment potential. However, harvest of too many of these conifers or hardwoods may diminish the future supply of LWD which is of a size suitable to physically function in adjacent stream channels. In addition, harvest of trees greater than 11 inches (28 cm) dbh along streams with bankfull widths wider than 8 feet (2.4 m) may diminish the future supply of functional pieces of LWD that wider channels require. If wood of a suitable size and amount is not delivered to the stream channel, further loss of pools, spawning habitat and cover is possible.

Additional Comments:

See the green line on Map CMD1 for the extent of causal mechanism D1 in the WAU.

Channel sensitivity to gains and losses of wood is variable throughout the watershed. Table CMD1 presents the percent of each GMU in Resource Sensitivity D1. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

TABLE CMD1. Percent of each GMU in Resource Sensitivity D1.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Percent of GMU in Resource Sensitivity D1
High	Lower LFC	1	20.6
	Government Flats	2	20.3
	Moderate size, Moderate Gradient	3	28.1
Moderate	Western Transport	4	32.7
	Eastern Transport	5	40.8
Low to Moderate[1]	Small, Steep Headwater	6	37.7

[1]Moderate channel sensitivity to wood applies to the fish-bearing portion of this GMU.

Management Objective:

Maintain sufficient large trees for LWD recruitment to the stream.

PRESCRIPTION

- Continue to manage riparian areas applying September 1994 Oregon Stream Rules
  - Mark a variable width band from the stream outward (within RMA) until basal area targets are achieved. Attempt to:
    - ◊ Leave trees leaning towards channel,
    - ◊ Maintain pre-existing stand diameter distribution to extent possible.
  - Certain situations may call for a variable width band (riparian area) in order to encompass special features or resource sensitivities (e.g., stream adjacent wetlands, unstable "hollows").
  - Avoid logging activities within marked "band." Possible exceptions, when the marked area may be entered, include:
    - ◊ Safety hazards (e.g. snag leaning into harvest unit),
    - ◊ Skyline corridors.
- Consider using leave tree selection as a method of recruiting potential LWD outside of the riparian buffer. Leave trees may include large "leaners" which may eventually fall into the stream.

Justification for Prescriptions:

The stream habitat survey shows the areas addressed in this causal mechanism have high LWD recruitment potential. The prescriptions are designed to maintain this desirable condition where it is present. The prescriptions provide for maintenance of a sufficient number of large trees to supply the adjacent channel. Marking a riparian band, within which logging activities are restricted, ensures that a diameter distribution is maintained. The diameter distribution includes large conifers required for LWD recruitment and of sufficient size to remain in the channel. Leaving trees leaning toward the channel further ensures LWD entry to the channel.

Monitoring:

N/A

Riparian Resource Sensitivity D2:

Hardwood-dominated stands.

CAUSAL MECHANISM REPORT

Situation Summary:

Some stream-adjacent stands are dominated by hardwoods as a result of past management practices. The existence of conifers prior to management can be inferred from historical air photos as well as the presence of conifer stumps within hardwood stands. In general, hardwoods, especially red alder, are often too small and do not persist within stream channels. Large diameter wood is required to sort and store gravel, increase pool depth and frequency, and create cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, wood of a size and quantity to affect channel morphology and therefore physical fish habitat may be limited. In some reaches, physically functioning in-channel LWD is currently present, but over time this will decay or be transported out of the system from high flow events. The adjacent hardwood dominated riparian areas in these reaches are not able to provide a source of persistent in-channel wood.

Triggering mechanism:

Past forest practices have removed extensive amounts of stream-adjacent conifers throughout the WAU. The resulting hardwood-dominated stands have only low to moderate near-term recruitment and generally do not provide long-term channel stability that coniferous LWD can provide. In addition, harvest of trees greater than 11 inches (28 cm) dbh along streams with bankfull widths wider than 8 feet (2.4 m) may diminish the future supply of physically functioning pieces of LWD that these channels require.

Additional Comments:

See the blue line on Map CMD1 for the extent of causal mechanism D2 in the WAU.

Not all of these stands originated as a result of past management practices. Delineation of stand origin was not done; however, the origin of some stands is known. For example, Government Flats had a significant hardwood component prior to management.

Table CMD2 presents the percent of each GMU in Resource Sensitivity D2. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

TABLE CMD2. Percent of each GMU in Resource Sensitivity D2.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Percent of GMU in Resource Sensitivity D2
High	Lower LFC	1	6.1
	Government Flats[1]	2	75.0
	Moderate size, Moderate gradient	3	29.3
Moderate	Western Transport	4	14.7
	Eastern Transport	5	10.2
Low to Moderate[2]	Small, Steep Headwater	6	5.3

[1]Most of this GMU was dominated by hardwoods prior to management.
[2]Moderate channel sensitivity to wood applies to the fish-bearing portion of this GMU

Management Objectives:

Improve recruitment potential of LWD in hardwood dominated areas that are potential conifer sites.

PRESCRIPTION

- Evaluate hardwood dominated riparian areas prior to management activities in the vicinity. Judge potential for good conifer growth and operational feasibility of conversion to conifer for the site. For potential RMA rehabilitation, consider:
  - Prescriptions done in conjunction with harvest of adjacent unit.
  - Shade tolerant species where appropriate (evaluate on a site-by-site basis).
  - Take into consideration the hardwood components available for recruitment, (maple would not necessarily be a conversion candidate).
  - Well-stocked conifer regeneration adjacent to narrow hardwood dominated RMAs may have good long-term LWD potential. These areas need no further action beyond normal management activities.

Justification for Prescriptions:

Conifers are required to provide long-term LWD. These trees reach sufficient size to be relatively stable in most streams, and have a slower decay rate than most hardwoods. Our prescriptions, therefore, focus on conifer establishment.

In hardwood dominated riparian areas, we have outlined criteria to identify rehabilitation candidates. We believe rehabilitation using proven technology, done in conjunction with regularly scheduled management activities, is likely to be more successful and more rapid than "spot" rehabilitation of problem areas. Since all of this ownership is within a managed forest, access is available to ensure conifer establishment over time.

We are not attempting to convert all hardwood dominated riparian area to conifer. Many unmanaged watersheds have 50-70% of the riparian area in late successional species, with much of the remainder in pioneer (typically alder) species or young conifer due to disturbance. Hardwoods provide diversity and other benefits to stream habitat, such as rapid shading and detritus input. Bigleaf maple that fall into a stream often retain a root system and resprout, providing long-term LWD to the channel.

In some areas, well-stocked conifer has already been planted adjacent to narrow hardwood dominated riparian areas. These areas need no further action since the conifer will grow to a size and number to provide adequate LWD recruitment. We may, however, precommercially or commercially thin selected areas to accelerate conifer establishment.

Monitoring:

Monitor the effectiveness of representative hardwood conversions.

Riparian Resource Sensitivity D3:

Small-diameter mixed and conifer-dominated riparian stands.

CAUSAL MECHANISM REPORT

Situation Summary:

Some riparian areas are dominated by small-diameter conifer and mixed conifer and hardwood stands, which are not ready to contribute large wood to stream channels. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, wood of a size and quantity to affect channel morphology and therefore physical fish habitat may be limited.

The small-diameter conifer stands could conceivably provide recruitable wood within 100 years, depending on riparian condition and management practices. Mixed stands may take longer than 100 years to get medium to large-diameter conifers due to light and nutrient competition from hardwoods and shrubs.

Triggering mechanism:

Several mixed stands originated due to natural conditions as well as riparian harvest. Small-diameter conifer stands largely exist as a result of regeneration after past timber harvest in riparian areas. In addition, future harvest of trees greater than 11 inches (28 cm) dbh along streams with bankfull widths wider than 8 feet (2.4 m) may diminish the supply of physically functioning pieces of LWD that these channels require.

Additional Comments:

See the red line on Map CMD1 for the extent of causal mechanism D3 in the WAU.

The following table presents the percent of each GMU in Resource Sensitivity D3. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

TABLE CMD3. Percent of each GMU in Resource Sensitivity D3.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Percent of GMU in Resource Sensitivity D3
High	Lower LFC	1	10.6
	Government Flats	2	4.7
	Moderate size, Moderate gradient	3	26.0
Moderate	Western Transport	4	45.6
	Eastern Transport	5	49.0
Low to Moderate[1]	Small, Steep Headwater	6	57.0

[1]Moderate channel sensitivity to wood applies to the fish-bearing portion of this GMU

Management Objective:

Improve recruitment potential of LWD in small diameter mixed conifer and hardwood, and small diameter conifer riparian stands.

PRESCRIPTION

- Evaluate riparian area in conjunction with management activities for possible enhancement.
  - Consider thinning (pre-commercial thinning or commercial thinning) to accelerate conifer growth.
  - Consider hardwood overstory control to release understory conifer.
- Continue to manage riparian areas applying September 1994 Oregon Stream Rules
  - Mark a variable width band from the stream outward (within RMA) until basal area targets are achieved. Attempt to:
    - ◊ Leave trees leaning towards channel
    - ◊ Maintain pre-existing stand diameter distribution to extent possible
  - Certain situations may call for a variable width band (riparian area) in order to encompass special features or resource sensitivities (e.g., stream adjacent wetlands, unstable "hollows")
  - Avoid logging activities within marked "band". Possible exceptions, when the marked area may be entered, include:
    - ◊ Safety hazards (e.g. snag leaning into harvest unit)
    - ◊ Skyline corridors
- Consider using leave tree selection as a method of recruiting potential LWD outside of the riparian buffer. Leave trees may include large "leaners" which may eventually fall into the stream.

Justification for Prescriptions:

In most cases the small diameter mixed stands and conifer dominated stands are younger stands that will grow into a more favorable condition for LWD recruitment with no management intervention. The prescription dealing with enhancement addresses opportunities for accelerating height and diameter growth on these stands through silviculture. These silvicultural activities can be cost effective if done in conjunction with regularly scheduled management activities.

The causal mechanism defines small diameter as trees with a dbh of less than 12 inches. In some cases this could encompass merchantable timber of rotation age. The prescriptions dealing with managing riparian areas in relation to harvest units were added to cover this situation.

Monitoring:

Monitor the effectiveness of representative riparian enhancements.

Riparian Resource Sensitivity D4:

Sparse conifer and mixed stands.

CAUSAL MECHANISM REPORT

Situation Summary:

Conifer and mixed riparian stands that are considered "sparse" lack sufficient sources of recruitable wood due to timber harvest and/or roads. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, wood of a size and quantity to affect channel morphology and therefore physical fish habitat may be limited. Since stand density is low, an adequate supply of wood is currently lacking. Where a road is causing a stand to be sparse, recruitment potential will continue to be low into the future. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous as well as residents fish species.

Triggering mechanism:

These stands have low to moderate near term recruitment potential due to sparse occupancy of the site as a result of timber harvest and roads. In addition, harvest of trees greater than 11 inches (28 cm) dbh along streams with bankfull widths wider than 8 feet (2.4 m) may diminish the future supply of physically functioning pieces of LWD that these channels require.

Additional Comments:

See the yellow line on Map CMD1 for the extent of causal mechanism D4 in the WAU.

Table CMD4 presents the percent of each GMU in Resource Sensitivity D4. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

TABLE CMD4. Percent of each GMU in Resource Sensitivity D4.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Percent of GMU in Resource Sensitivity D4
High	Lower LFC	1	62.7
	Government Flats	2	0
	Moderate size, Moderate gradient	3	15.6
Moderate	Western Transport	4	7.0
	Eastern Transport	5	0
Low to Moderate[1]	Small, Steep Headwater	6	0

[1]Moderate channel sensitivity to wood applies to the fish-bearing portion of this GMU.

Management Objective:

Improve recruitment potential of LWD in sparse conifer and sparse mixed stands

PRESCRIPTION

- Evaluate sparse conifer and mixed stand riparian areas prior to management activities. Consider:
  - Planting conifers if site allows
  - Controlling brush to allow conifers to become established
  - Planting hardwoods if it is a hardwood site
- If sparse condition is the result of a streamside road, consider leaving additional leave trees in the riparian area on the opposite bank, or in the vicinity where there is a high likelihood of recruitment.
- Continue to manage riparian areas applying September 1994 Oregon Stream Rules
  - Mark a variable width band from the stream outward (within RMA) until basal area targets are achieved. Attempt to:
    - ◊ Leave trees leaning towards channel,
    - ◊ Maintain pre-existing stand diameter distribution to extent possible.
  - Certain situations may call for a variable width band (riparian area) in order to encompass special features or resource sensitivities (e.g., stream adjacent wetlands, unstable "hollows").
  - Avoid logging activities within marked "band". Possible exceptions, when the marked area may be entered, include:
    - ◊ Safety hazards (e.g. snag leaning into harvest unit),
    - ◊ Skyline corridors.
- Consider using leave tree selection as a method of recruiting potential LWD outside of the riparian buffer. Leave trees may include large "leaners" which may eventually fall into the stream.

Justification for Prescriptions:

The sparse conifer and mixed stand riparian areas are located primarily in the Lower Little Fall Creek GMU in this WAU. The planting enhancement work prescribed requires site specific review to determine its potential for success. The hardwood species, hardwood conifer mix, and conditions upstream and down from the candidate area all need to be taken into consideration. Interplanting shade tolerant conifers or hardwoods as the site warrants would increase density and improve long-term LWD potential.

Steam adjacent roads within 100 feet of the stream limit the area available for LWD recruitment. The area between the road and the stream is often not suited for rehabilitation or enhancement. Leaving additional trees in the opposite bank riparian area or in a riparian area in the vicinity where there is a good chance for recruitment will help mitigate the loss of LWD potential from the road.

Variable width buffers can be used to recruit additional LWD candidates outside the riparian area. Using this option, trees that definitely have the potential to act as functional LWD over time can be included in the buffer zone. On the other hand, trees leaning away from the stream that are not candidates for LWD recruitment could be harvested if adequate basal area is maintained.

Monitoring:

Monitor the effectiveness of representative riparian enhancements.

Stream Channel Resource Sensitivity

None identified.

CAUSAL MECHANISM REPORT

None.

Fish Habitat Resource Sensitivity F1:

Culverts limiting fish passage.

CAUSAL MECHANISM REPORT

Situation Summary:

Road crossing culverts that are impassable or partially passable are located in the known fish-bearing stream network and in stream reaches that are potentially fish-bearing.

The ability of trout to move within a watershed free of artificial barriers is important for several reasons:

- Fish must be able to access various habitat types. For example, spawning habitat may not be distributed throughout a system and fish may need to move up or down stream to access these areas.
- Fish must also be able to move to adjust to changing habitat conditions such as temperature or food availability.
- Fish may access different portions of the watershed that are seasonally available. For example, the ability of fish to access intermittent streams or upstream areas that are perhaps marginal habitat in summer but important during higher flow periods. Likewise, during declining flows fish may need access to mainstream reaches.

On a larger scale, entire populations can be impacted by artificial barriers. Barriers can reduce or eliminate the continuity of stream networks that are important to genetic interaction. This can cause population fragmentation, decreasing gene flow and genetic integrity, and, ultimately, the persistence of populations.

Triggering mechanism:

Impassable and partially passable road-culverts hinder fish movement.

Location:

See Map F2 (Appendix F) for locations of culverts and Table CMF1 for details. Additional information is provided in the Fish Habitat Module.

TABLE CMF1. Culverts within the known fish-bearing network that hinder fish movement (all culverts are round metal pipes without baffles). Information is based on fieldwork during this analysis and incorporates observations of other Assessment Team members.

GMU	SEG #	*Culvert #	Stream	Fish use	Road #	Comment
6	16	1	LFC	unknown	530rd	drop. = hind.
4	37	2	LFC	steelhead	main rd	hydro control possible hindrance
4	71	3	LFC Trib.	cutthroat	main	.5m drop=hindrance
6	208	4	Norton Trib.	cutthroat	4050rd	hydro cont. 1ft drop=hindrance
4	220	5	LFC Trib.	cutthroat	5040rd	.5m drop=hindrance
4	253	6**	Sturdy	cutthroat	7040rd	bent with hydro.control, hindrance
2	310	7	LFC Trib.	unknown	USFS 1806-435	barrier--2 m drop
6	365	8	LFC Trib.	cutthroat	110rd	1ft drop to cascade-impassable
4	510	9	Hills trib.	cutthroat	main cr.	1.5m drop=impassable
3	528	10	Starks	unknown	400rd	1.5m drop to rock-impassable
4	533	11	Hills trib.	cutthroat	360rd	2ft drop to rocks not passable

*Culvert number corresponds to culvert identification number on Map F2.
**Culvert is now washed out but fill/cascade is still a barrier.

Additional Comments:

Based on likely fish distribution (Fish Habitat Module, Appendix F) most of these culverts occur in the resident fish use zone affecting mostly cutthroat trout. Steelhead movement may be hindered by some culverts (Table CMF1).

A complete survey of culvert passability was not conducted during this assessment. The number of culverts identified during this cursory inventory indicates that other road culverts that hinder fish movement are likely to be found during a more thorough effort.

Currently the extent of the fish-bearing network is incomplete. When the entire fish-bearing network is known, it is likely that more culverts hindering the movement of resident salmonids will be found.

The following characteristics should be considered when prioritizing road culvert or fish passage enhancement:

- species that may be impacted
- type of blockage (partial or complete)
- length of habitat that is rendered inaccessible

Management Objective:

Correct human caused barriers to fish passage.

PRESCRIPTION

- Survey culverts and identify fish passage issues.
  - Repeat survey periodically.
- Identify other barriers as encountered. Evaluate and propose action for correcting.
- Prioritize corrective action using the following guidelines:
  - Type of blockage (partial or complete), length and quality of the habitat rendered inaccessible,
  - Habitat impacted (fish species),
  - Culvert size and condition,
  - Evaluate all fish passage issues (across total ownership) when allocating resources to corrective actions.

Justification for Prescriptions:

Several barriers were identified during field work for the assessment portion of this watershed analysis. The assessment relies on aerial photography work and spot field checks. It is not a complete inventory of the watershed. Previous partial surveys have identified fish passage issues and these are being addressed. Performing a complete culvert inventory will allow barriers to be identified and prioritized for corrective actions.

Using the prioritization guidelines outlined in this prescription will ensure that the maximum benefit is gained with the resources available. Culvert size and condition are included as a priority consideration because we are trying to upgrade inadequate culverts on our ownership. If a culvert is undersized or rusted out it will be considered a higher priority than it would have been, all other things being equal.

Monitoring:

Acquire any fish survey results Oregon Department of Fish and Wildlife may do on areas above eliminated barriers.

Document corrected fish barriers.

Fish Habitat Resource Sensitivity F2:

Accurate typing of fish-bearing waters.

CAUSAL MECHANISM REPORT

Situation Summary:

Current forest practice rules that are applied to streams are based on stream type designations. These designations are dependent on fish-bearing status. Inaccurate stream typing can result in application of forest practices that may not adequately protect fish-bearing streams.

Triggering mechanism:

Incorrect stream type designations may lead to inadequate protection of fish-bearing waters.

Additional Comments:

An additional 5.5 stream miles were identified as fish bearing during this analysis based on fish sampling (Appendix F). Approximately 60 more stream miles are potentially fish bearing based on map features of gradient and drainage area. These waters currently are not recognized as fish-bearing according to the Oregon Department of Forestry Stream-Typing Map (Map SF1).

Although fish presence/absence has not been established in all waters of the WAU, an approximation of fish bearing status is made based on the protocol described in Oregon Department of Forestry 1996. This interim process is applied to all streams on Weyerhaeuser ownership (F. Williams, Weyerhaeuser pers. comm. 1997).

Management Objective:

Accurately type all streams for fish presence or absence.

PRESCRIPTION

- Conduct stream surveys as needed to support ongoing Oregon Department of Forestry and Oregon Department of Fish and Wildlife fish presence or absence work.
  - In the absence of a survey implement Oregon Department of Forestry interim rules,
  - Prioritize surveys in conjunction with management activities,
  - Incorporate survey results into GIS.

Justification for Prescriptions:

The last few summers we have contracted with a two person crew to do presence or absence surveys on our lands, targeting areas of upcoming management activities. This work supplements the stream surveys performed by ODF/ODFW. If management activities precede a stream survey then the ODF interim rules are used. The interim rules provide fish protection to streams that have greater than a hundred acres of drainage area, up to 20% gradient and do not have natural barriers to fish passage.

Monitoring:

N/A

Willamette Region

Road Maintenance Manual

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Current Road Maintenance Standards

Notes

Changes in personnel, operating procedures, and State regulations will require periodic modifications to this document. All changes will be made following the philosophy of the original document dated May 1, 1996.

No work will be done to meet these guidelines that will create environmental problems exceeding what currently exists in any particular situation.

Wood culverts are being treated as a separate project and budget, and will be administered by the Engineers.

Harvest Manager is defined as any Weyerhaeuser employee that has an operation that is engaged in removing a major forest product. This includes commercial thinning operations, timber cutting, harvesting, fiber recovery, and any other harvest activity that impacts the roads and/or ditches significantly.

The Land Use Department will be responsible for maintaining, as needed, the roads that are utilized for minor forest products harvesting (activities that Land Use controls).

If a required maintenance activity is not completed as scheduled for environmental, safety, or other reasons, the plat or note will be on file with the Engineers until the maintenance is complete.

The Engineers will maintain files on capital structures (bridges, etc.) as needed to meet recommended safety and structural inspection intervals.

For maintenance purposes, a STREAM is defined as any watercourse having live water during a use period.

Plan for Road Maintenance

If a road maintenance emergency occurs, the person finding the problem will take care of it or will ensure that the appropriate person is well aware of the situation. Do not assume the Engineer or other responsible party already knows about it.

Engineer

The Engineers will maintain active haul routes in cooperation with the Harvest Manager on an on-going basis. Other active use roads (defined nominally as 3 years prior to logging and 2 years post logging) that are not actively being hauled on will be maintained by the Engineers on a rotating basis with approximately ¼ of the roads in each Engineers area being checked and maintained each year. The Engineer will also identify and check potential trouble spots on all roads on an as-needed basis to prevent or minimize safety or environmental problems.

The Engineers will utilize the existing plan and procedures for maintaining the forestry roads that they are responsible for. This plan consists of an annual review of all roads under their responsibility with spending prioritized to meet environmental, then forestry needs. Cottage Grove will have the Foresters administering the information gathering with the Engineers responsible for the maintenance identified. Springfield is still reviewing the responsibilities.

The Engineers will have a storm patrol plan that will identify the conditions and locations for post-storm inspections and how the inspection duties will be assigned (appendix).

The Engineers will be responsible for auditing road maintenance activities to ensure the work is completed in a timely manner and that maintenance is done to the Standards (attached). Questions on road maintenance procedures or exceptions to the Standards will be reviewed with the Team Leader and Environmental Manager before being implemented. The Engineers will be responsible for periodically reviewing the Road Maintenance guidelines and making changes to reflect new external state or other rules, new procedures and/or products, and any changes in policy or job assignments within Weyerhaeuser.

Harvest Manager (H.M.)

The Harvest Manager will maintain the roads under his control (roads within the unit boundaries and non-haul roads impacted by the operation) to the Road Maintenance Standards. The Harvest Manager is responsible for coordinating with the Engineers for haul route maintenance. Maintenance deferred past the unit closure deadline, for environmental, safety, or other reason will be noted on a plat and maintained in a file by the Engineers (the Harvest Manager is still responsible for completing required maintenance).

Land Use (L.U.)

The Land Use Department will be responsible, in cooperation with the Engineers, for required maintenance resulting from their permit holders operations. Post-operation maintenance of Land Use activities is with the intent of bringing the road system used back to pre-operation conditions. Deferred maintenance will be noted on a plat and maintained by the Engineers (the Land Use Department is still responsible for ensuring required maintenance is completed).

Environmental Manager (E.M.)

The Environmental Manager will be responsible for monitoring road maintenance practices to ensure the work is consistent with the Maintenance Manual standards and watershed analysis prescriptions.

Responsibility for Road Maintenance

Pre-haul

The Engineers assume responsibility for active road maintenance 3 years prior to active hauling. The Engineer will improve the road, if possible, to meet current road standards, given budget levels and priorities, and will include said road in his active maintenance plan until the road is not used for active operations for 2 years. Existing roads not brought up to current road standards will at a minimum meet safety and environmental needs. Note that maintenance can be transferred directly from the forestry category to active if the Harvest Manager, in cooperation with the Engineer, determines the existing roadway adequately meets their needs and is environmentally sound (this typically refers to thinning and other low volume operations).

Active Unit

Once the unit is active, the Harvest Manager is responsible for all maintenance required within the unit boundaries and on all non-haul roads impacted by the harvest operation. The Harvest Manager is responsible for coordinating maintenance required on the haul route outside the unit with the Engineers.

Unit Closure

The Harvest Manager is responsible for in-unit road and ditch clean-up. The Harvest Manager will coordinate with the Engineers regarding future status of in-unit roads and the required level of maintenance on each road. The Harvest Manager should perform unit cleanup (within 30 days on winter units completed between September and May and by October 15, on summer units completed between June and August) after which in-unit roads are handed over to the Engineers. Units not cleaned up within the designated period will be kept on file with the Engineers until required cleanup is complete. Delayed cleanup is acceptable so long as no safety or environmental problems are anticipated. The Engineers are responsible for post-harvest haul road maintenance, which should be coordinated with the Harvest Manager to maximize equipment utilization. The Engineers will maintain these roads until the next use or will turn the roads back to forestry maintenance two years after active use is complete.

Forestry

The Engineers will be responsible for all forestry road maintenance. The foresters and all other users of forestry roads are expected to coordinate with the Engineers for any needed maintenance for their activities. (See Notes regarding Land Use.)

Other Activities

For any operations not covered above, the operator has responsibility for notifying the Engineers and ensuring that maintenance is complete as required by the Standards. All operations are held to the post-operation cleanup deadlines. Exceptions to the post-operation guidelines for completion of required maintenance will be on file with Engineers (as noted in Unit Closure) until cleanup is complete (operator is still responsible for completing maintenance).

Chart for Road Maintenance Responsibility

Activity	Responsibility
Clear-cut Pre-haul	Engineer (within 3 year pre-haul period)
Active Unit: Inside unit and impacted non-haul roads	Harvest Manager
Active Unit: Outside unit haul roads	Harvest Manager, in cooperation with Engineer
Unit Closure and Post-Haul (to 2 years post logging):	
Inside Unit	Harvest Manager completes unit cleanup, then to Engineer.
Outside Unit	Engineer, in cooperation with Harvest Manager.
Forestry Use:	
Active and Inactive	Engineer
Abandonment	Engineer, in cooperation with State Forestry
Other Use	
Any major forest product (outside of clear-cut harvest)	Operator, in cooperation with Engineer.
Minor forest products	Land Use, in cooperation with Engineer.

WILLAMETTE REGION

ROAD MAINTENANCE CLASSIFICATIONS AND SPECIFICATIONS

These road maintenance classifications and specifications are to be used to maintain roads that were built or will be built to meet the road standards that are currently in place. Upgrading a road to a higher standard (rocking a dirt road) or downgrading (abandonment of a road), i.e., Road Type changes (see chart and definitions in Appendix), is not considered maintenance. Changing maintenance levels, either to a higher or lower level (active v. forestry), is not considered a change in Road Type.

The Engineers will be responsible for determining Road Type. The Foresters, Planners, Harvest Managers, and Construction Supervisors will have input in determining Road Type. The Engineer will develop a record of Road Type determinations (utilize GIS, when available) with notes on exceptions to current standards for specific roads that cannot be repaired within current budget or timing parameters (e.g., paved Cottage Grove truck road). The Road Type determinations will be used to evaluate if required maintenance on a road or road system is maintenance or reconstruction. <u>The Road Type determinations and record keeping will be done as time and resources are available</u>.

LEVEL 1 MAINTENANCE

Goal of Level 1 Maintenance is to allow unrestricted access for harvest activities at any time of the year, Road Type and snow permitting. It is intended, budgets and priorities allowing, that existing roads will be brought up to current new road standards as they are prepared for log haul. The maintenance standards here rely heavily on the standards for new roads, a copy of which is included as an appendix.

PRE-HAUL

1. New roads to current road standards for Road Type (budget and priorities allowing).

2. Existing roads. Engineer is responsible for ensuring that pre-haul standards are met. Variation from the standard on existing roads is allowable but requires involvement of the user and Engineer and must meet safety and environmental guidelines. An example of a variation from standard might be a road width less than standard. These variations from standard will be documented and filed with the Engineers as time and resources allow.

    A. Grade/Rocking/Surface

    Grade
    1. Old design flaws removed/repaired as practical. Engineer evaluation for safety and environmental issues.

    Rocking
    1. Replacement rock added, as needed, to bring road surface to current design standards for Road Type (budget and priorities allowing).

    Surface
    1. Road surface crowned and shaped to maintain surface integrity, drainage, and design speeds per road standards for Road Type.

2. No berm shall be left on the inner or outer edge of the roadway except by design for surface water control or dust abatement materials containment.

B. Ditches/Culverts

Ditches (*see diagram on next page*)

1. The goal in doing any ditch work is to establish and maintain an adequate waterway while minimizing the potential for silt. Ditches will be pulled and reworked only if the road surface shows evidence that the existing ditches are inadequate. If ditches require work, the existing cut-banks will not be undercut. Material from ditch cleaning operations shall not contaminate rock surfaces (generally, will require bunching and scooping of ditch debris.)
2. If the actual road width exceeds the standard for that road type, such that water will not drain freely from the shoulder, the shoulder will be out-sloped, ditched or otherwise drained to minimize standing water on the shoulder. The objective is to avoid having standing water adjacent to or in the traveled roadway.

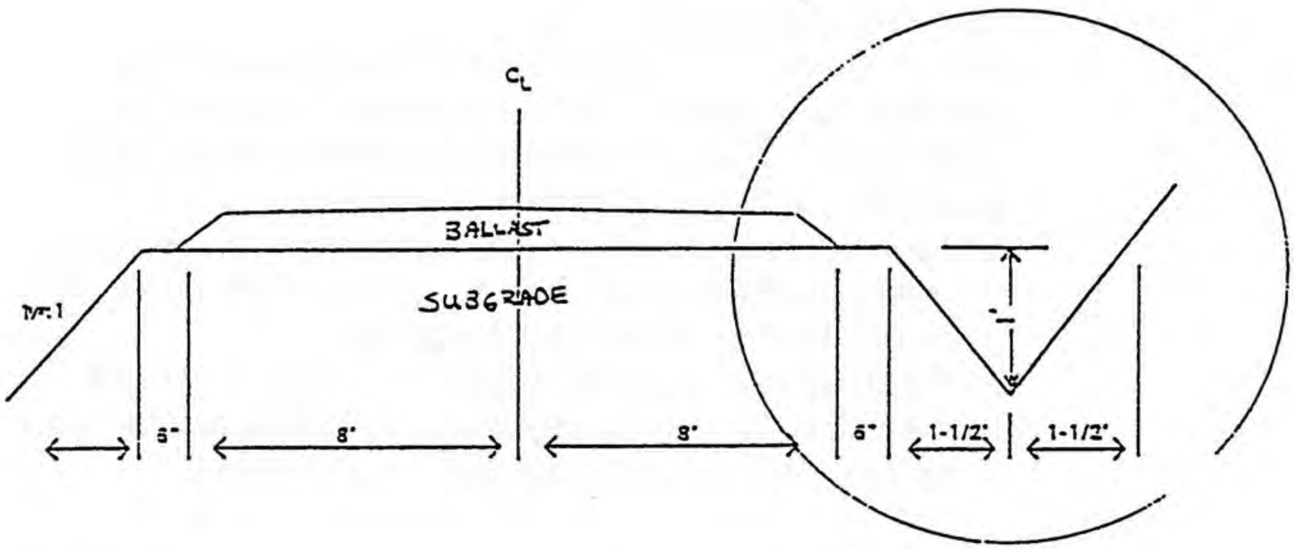
Culverts

Culvert cross drains will have minimum 90 % of the original opening (inlet and outlet). No culvert sized smaller than current road and State Forestry standards shall remain in place without Engineer approval. Additional culverts will be added as needed to meet current road standards (budget and priorities allowing). If ditches require work to meet drainage needs, culverts will have catch basins that meet current road standards, if that best meets drainage and environmental needs. Outlets for new culverts shall terminate on non-erosive materials, such as rip rap or in natural stream beds. All culverts on active roads will, at a minimum, meet State Forestry rules for when they were installed.

C. Other

Roadside brushing, as needed, to meet current road standards for roadway clearance and sight distance.

Typical Roadbed Section



DURING HAUL

1. All haul roads.

   A. Grade/Rocking/Surface

   Grade

   Normally would expect to have no required maintenance on the sub-grade during haul activities.

   Rocking

   Predetermined post-haul status of road system will determine level to which pre-haul road standards for rock depth and width are maintained during haul. Engineers will indicate to the Harvest Manager the post-haul status of the road.

   Surface

   1. Integrity of surface shall be maintained by regular motor patrol (grader) initiated by visual inspection of the road surface while hauling. Conditions which could result in safety or environmental risk will have priority for action.
   2. Harvest Manager is responsible for initiating maintenance activities. As a guide, the following rules-of-thumb may be useful for the Harvest Manager in evaluating when to initiate surface maintenance activities. Call for a grader when:
      A. Potholes or washboard in wheel tracks exceed four (4) inches in depth, and are of such frequency that traffic tends to widen the traveled way to avoid the deformities.
      B. Wheel ruts caused by use exceed four (4) inches in depth.
      C. The surface does not drain (water is trapped in the wheel ruts for long distances) and substantially lost its crown.

      This standard applies to the haul route outside the unit and as much of the haul route inside the unit as is practicable, given logging conditions.

B. Ditches/Culverts

Ditches

The goal in doing any ditch work is to establish and maintain an adequate waterway while minimizing the potential for silt. As long as ditches are open and leading to a working culvert or lead-off ditch, no maintenance will be required. Cut bank sloughing and debris generated during cutting and logging that enters ditches will be removed as necessary to minimize the potential for safety or environmental risk (such as sediment delivery to a fish stream).

Culverts

Culvert inlets and outlets will be maintained during harvest operations. The Harvest Manager will be responsible for repair or replacement of damaged culverts inside the unit during their operations. Corrective action can be delayed until post-operation cleanup if the Engineer concurs that there is no safety risk and the environmental risk is acceptable.

C. Other

Dust Control

1. Consider dust control measures if dirt or graveled road in use is within 400 feet of a home, other business, or public roadway that may be affected by the dust or if dust is known to be a problem. The quantity of use that triggers dust control measures is situation specific but should be monitored closely to avoid neighbor complaints or possible unsafe conditions.
2. Listed below are procedures to follow in preparing a road for dust control products.
   A. Grade and shape road so that the traveled portion of the roadway is defined, including turnouts, with at least one (1) inch of rock fines on the surface. In addition, a two (2) to three (3) inch berm should be left on both sides of the traveled roadway to serve as a barrier to dust control product (includes mud from watering) running into ditches or streams. The height of the berm will be directly related

to the potential for leakage of the product into streams or any other area where product is not desired.

B. Apply the dust control product according to the manufacturers' recommendations. Depending upon the situation, the Engineer may alter the manufacturers' recommendations in order to accommodate a given set of circumstances (such as greater environmental protections).

Snow Plowing

1. The Harvest Manager will be responsible for determining the need to snow plow.
2. Snow plowing is to be done primarily using motor graders. Snow will be plowed to the outside edge of the road. However, if the snow has a high proportion of surface rock, a small berm containing the snow and rock can be graded to the inside shoulder so that the rock can be retrieved after snow melt.
3. Snow can be plowed with a cat but not down to the rock surface. The final snow plowing must be done with a grader to minimize damage to the road surface.
4. Salt will not be used except in an emergency situation. If salt is required, the condition that required the use of salt should be repaired as soon as possible to avoid future use of salt. Any use of salt will be noted to the Engineers with details of the circumstances which created the need.

Other

Any other necessary activities will be coordinated with the appropriate internal and external resources prior to the need. The party with the need will be responsible for initiating and monitoring the requested activity.

POST-HAUL

1. All haul roads.

   A. Grade/Rocking/Surface

      1. After haul is complete, determine the Road Type for the post-haul road and maintain to that standard.
      2. If Road Type is undetermined after haul, use the interim standards listed below to maintain the ditches and culverts until the status of the road is decided.

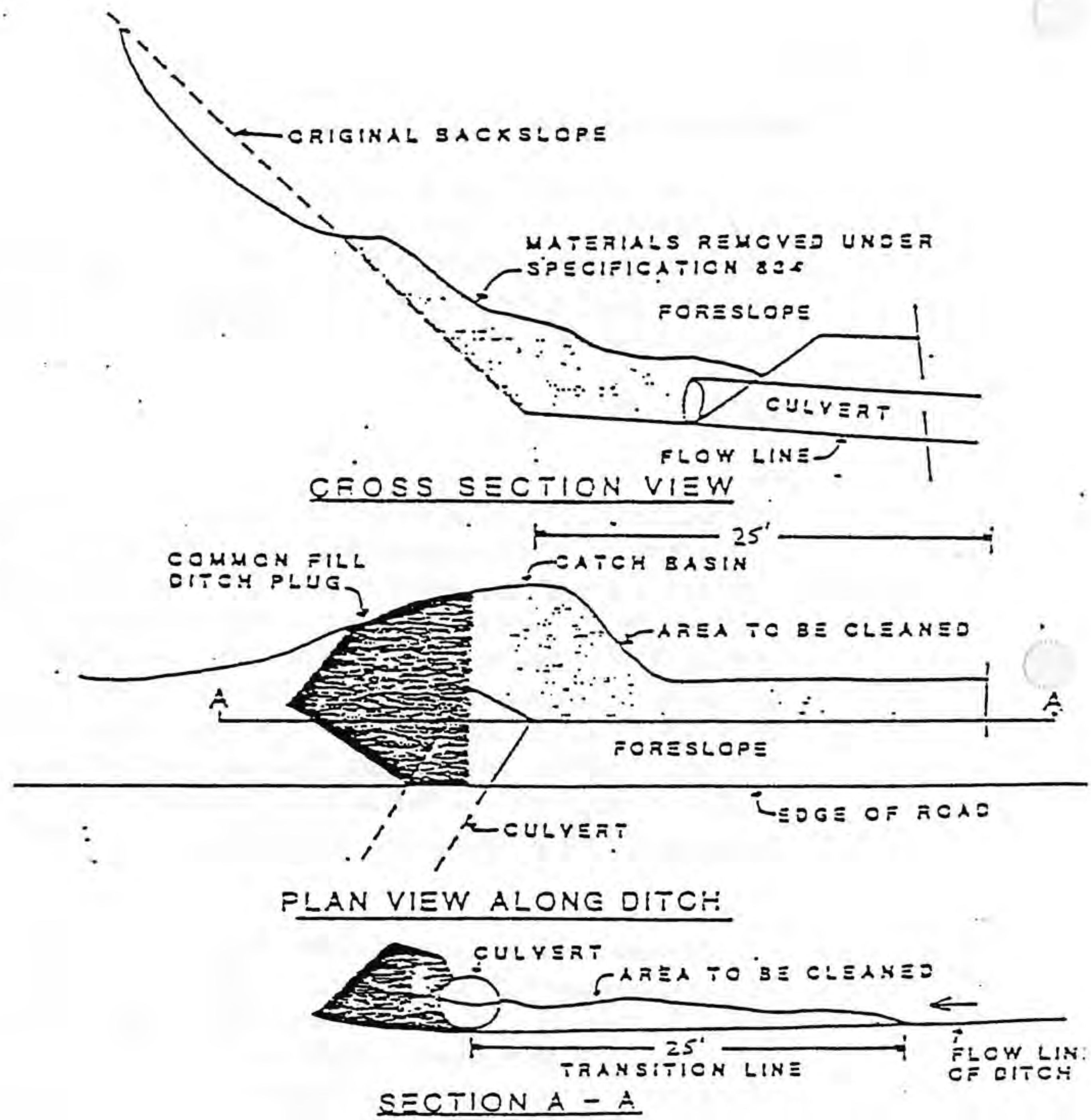
   B. Ditches/Culverts

      Ditches

      The goal in doing any ditch work is to establish and maintain an adequate waterway while minimizing the potential for silt. Ditches will be pulled and reworked only if the road surface shows evidence that the existing ditches are inadequate. Woody debris that may block cross-drain culverts should be removed from around the culvert head. Minimize machine work in ditches as practical. If ditches require machine work, the existing cut-banks will not be undercut. Material from ditch cleaning operations shall not contaminate rock surfaces (will require bunching and scooping of ditch debris to avoid contaminating rock surface).

      Culverts

      Culvert cross drains will have minimum 90% of the original opening (inlet and outlet). Other culverts will, at a minimum, meet State Forestry rules for when they were installed. Culvert catch basins will be returned to original road standard specifications if that best meets drainage and evironmental needs. Culvert out-falls will be checked to verify that water flowing through the culvert will terminate in a stream bed or on non-erosive materials.



TYPICAL SECTION OF CATCH BASIN

AND TRANSITION AREA

LEVEL 2 MAINTENANCE

The goal of Level 2 Maintenance is to allow access for Forestry activities at any time of year, Road Type and snow permitting. It is recognized that many miles of road in our system may not meet the Standards listed below. Roads that fall within this maintenance category that do not meet the Standards will be brought up to the Standard on a safety, environmental, and need-of-use basis (budget permitting). This will be done using information developed from road audits and projected needs from the Foresters. Where these guidelines may conflict with State forestry rules, Legislative mandates, or changing Weyerhaeuser guidelines, these standards will defer to outside rules and these guidelines will be brought into conformance as soon as possible.

A. Grade/Rocking/Surface

Grade

1. Old design flaws or other problems with the grade are left if, in the Engineers opinion, roadway is safe to drive and environmentally sound. Stable slides and slumps should be removed only if they constitute a safety or environmental hazard. However, a minimum surface width of 10 feet, with allowance for off tracking in corners and not including ditches, is required.
2. No berm will be left on the inner or outer edge of the roadway except by design for surface water or dust abatement material containment. If an unwanted berm has established timber on it, the Engineer can create "water-outs" (cuts through the berm) to relieve water in the road without having to remove the entire berm.
3. All dead-end roads will have a truck turnaround adequate to turn a loaded fire truck (truck only, not including trailers) at or near the end landing. In addition, all roads will have a truck turnaround approximately every 2,500 feet (this can include junctions or other turnaround opportunities).

Rocking

Rock will be replaced on roads if the original road was rocked or if rock is needed for environmental reasons. Rock replacement will be done so that the affected section of road will match existing rock on either end of the repair. Rock replacement will typically be done after culvert repair or replacement, slide repair, or other work that removes or contaminates the road surface. The completed repair is only required to match the <u>current</u> standard of the road, even if it does not meet the standards detailed here. (Refer back to the Goals to evaluate the appropriate standard for the completed repair.)

Surface

1. No surface grading will normally be required. A grader can be used to sweep large rocks and other debris from the running surface. No object over four (4) inches above the surface will remain in the usable traveled way (does not include water-bars).
2. Repairs which remove or otherwise alter the road surface will be graded with the objective of bringing the road back to its current or desired standard.
3. Grading of the road surface will also be done if the Engineer determines that the existing condition of the road surface constitutes a safety or environmental risk.

B. <u>Ditches/Culverts</u>

Ditches

1. The goal in doing any ditch work is to establish and maintain an adequate waterway while minimizing the potential for silt. Ditches will be pulled and reworked only if the road surface shows evidence that the existing ditches are inadequate. Ditches should not be used to channel stream flows except by design and then only with Engineer approval. If ditches require work, the existing cut-banks will not be undercut. Material from ditch cleaning operations shall not contaminate rock surfaces (generally, will require bunching and scooping of ditch debris).
2. Water bars are an acceptable alternative to ditch repairs in the last 20 stations of a dead-end road. The most environmentally sound and cost-effective method of controlling the ditch and surface runoff should be used (whether it is ditching, water-barring, or a combination of both). (See diagram of recommended water bars.)

3. Forestry roads with a dirt running surface exceeding ten (10) percent grade and/or that show significant surface run-off shall be surface water barred as priorities allow. Recommended spacing is at least every two hundred (200) feet, with water being directed into the ditch or over the outer edge of the road onto stable non-erosive material.
4. If the actual road width exceeds the standard for that road type, such that water will not drain freely from the shoulder, the shoulder will be out-sloped, ditched or otherwise drained to minimize standing water on the shoulder. The objective is to avoid having standing water adjacent to or in the traveled roadway.

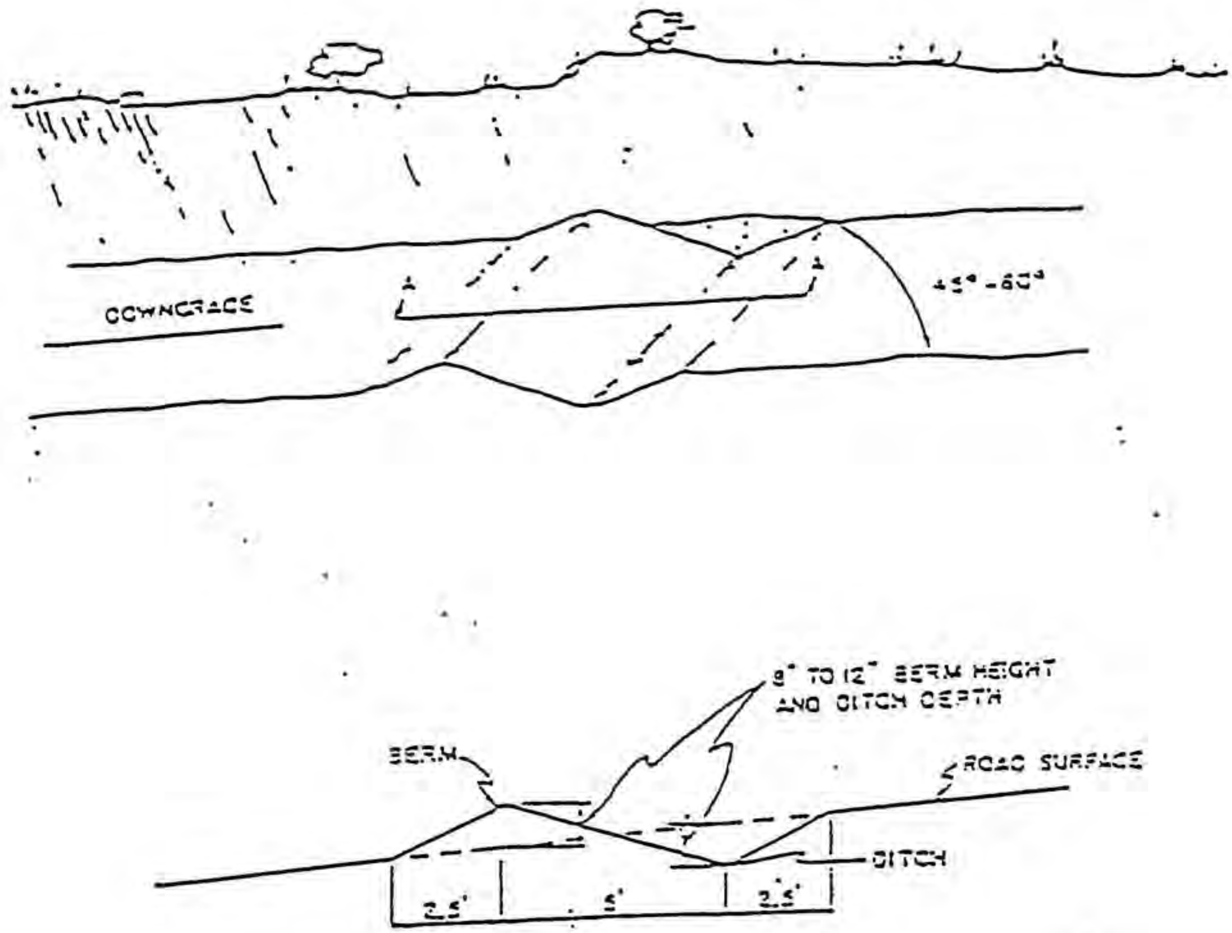
Culverts

1. Culvert cross drains will have a minimum 90% of the original opening (inlet and outlet). Cross-drain culverts that are damaged beyond reasonable repair may be replaced with cross-ditch water bars on the last 20 stations of any dead-end road. The determination of water-bar v. CMP will be based on access needs, environmental concerns, and cost.
2. Culverts for stream crossings will also have a minimum 90% of the original openings or to State required cross-sectional opening, whichever is greater. Unsalvageable culverts will be replaced to current new road standards for the Road Type. The catch basin will be to new road standards and non-bedded debris up to twenty-five (25) feet upstream will be removed or reduced to a size that will pass through the culvert cross-ways. Damaged stream-crossing culverts will be replaced with new culverts or other drainage structures, not with cross-ditch water bars.

C. <u>Other</u>

Roadside Brushing

Roadside brushing will be done on Forestry roads with the objective of removing all brush, limbs, and trees that prevent or hinder fire truck access. Generally, brushing will be done to create a roadway opening that extends four (4) feet beyond either side of the traveled roadway and a minimum thirteen (13) feet



TYPICAL WATER BAR DETAIL

above the road surface (see diagram). Turnouts and turnarounds will be brushed, but sight lines will not be improved except by Engineer direction.

Dust Control

1. Consider control measures if dirt or graveled road in use is within 400 feet of a home, other business, or public roadway that may be affected by the dust, or if dust is known to be a problem. The quantity of use that triggers dust control measures is situation specific, but should be monitored closely to avoid neighbor complaints or possible unsafe conditions.
2. Listed below are procedures to follow in preparing a road for dust control products.
   A. Grade and shape road so that the traveled portion of the roadway is defined, including turnouts, with at least one (1) inch of rock fines on the surface. In addition, a 2-3 inch berm should be left on both sides of the traveled roadway to serve as a barrier to dust control product (includes mud from watering) running into ditches or streams. The height of the berm will be directly related to the potential for leakage of the product into streams or any other area where product is not desired.
   B. Apply the dust control product according to the manufacturers' recommendations. Depending upon the situation, the Engineer may alter the manufacturers' recommendations in order to accommodate a given set of circumstances (such as greater environmental protections).

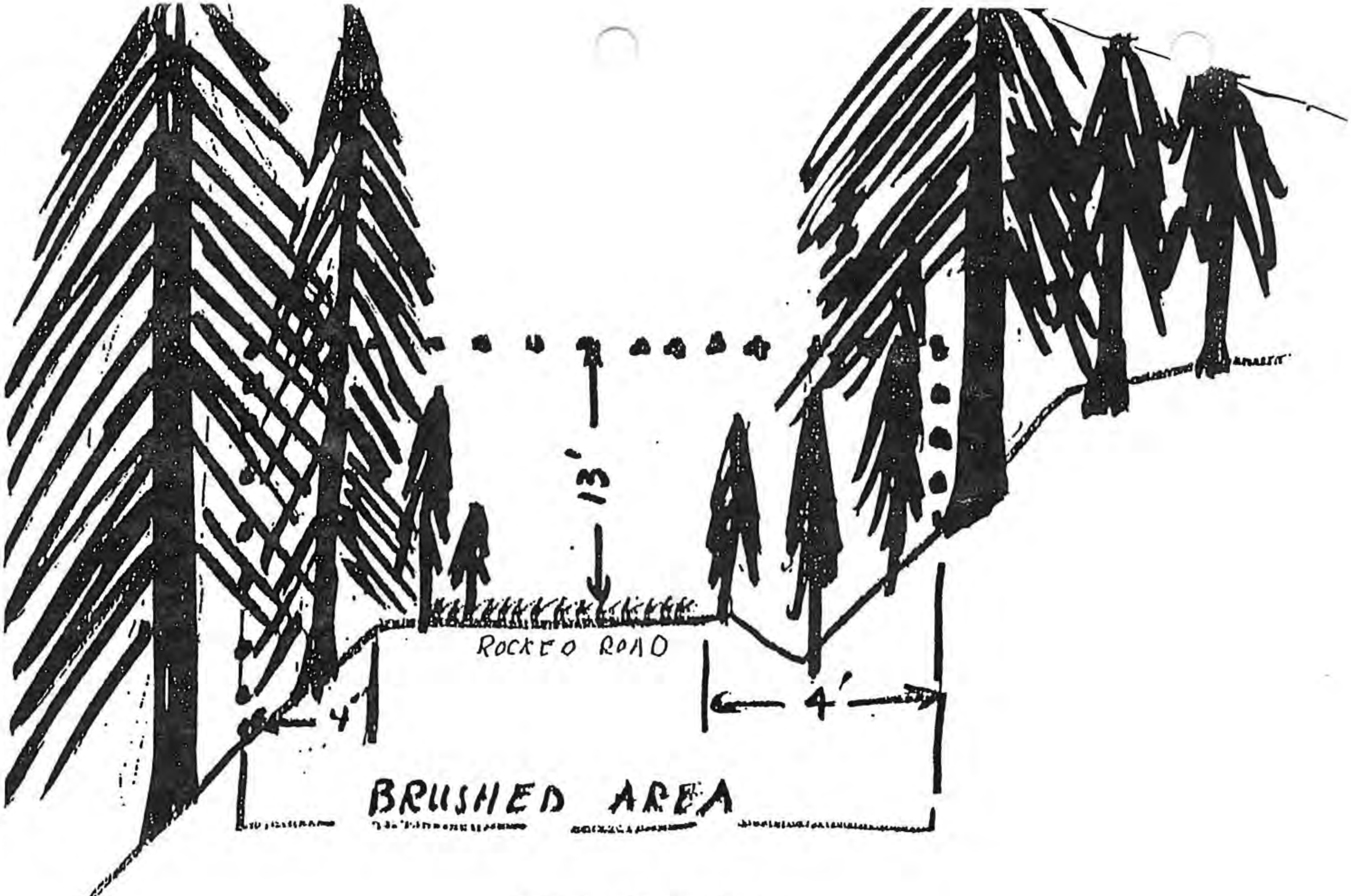
Snow Plowing

1. The user will be responsible for determining the need to snow plow.
2. Snow plowing is to be done primarily using motor graders. Snow will be plowed to the outside edge of the road. However, if the snow has a high proportion of surface rock, a small berm containing the snow and rock can be graded to the inside shoulder so that the rock can be retrieved after snow melt.
3. Snow can be plowed with a cat but not down to the rock surface. The final snow plowing must be done with a grader to minimize damage to the road surface.

4. Salt will not be used except in an emergency situation. If salt is required, the condition that required the use of salt should be repaired as soon as possible to avoid future use of salt. Any use of salt will be noted to the Engineers with details of the circumstances which created the need.

Other

Any other necessary activities will be coordinated with the appropriate internal and external resources prior to the need. The party with the need will be responsible for initiating and monitoring the requested activity.



BRUSHING

FOREST ROAD MAINTENANCE

LEVEL 3 MAINTENANCE

The goal of Level 3 Maintenance is to preserve the basic structure of the roadway but not guarantee access over the rotation. This standard will gradually allow the road to fall to a level such that only backhoes, ATVs, etc. can access the road. The road will be semi-permanently blocked at the beginning with the expectation that it will be used at the next rotation; otherwise, it will not handle vehicle traffic until then.

A. Grade/Rocking/Surface

Grade

Only such work as is needed to ensure a stable road base will be performed. A minimum road width of seven (7) feet will be maintained to ensure backhoe access.

Rocking

No rocking will be done at this maintenance level except as needed to help stabilize drainage structures and to allow access for maintenance purposes.

Surface

1. No grading will be performed.
2. The entrance to the road will be semi-permanently blocked by the Engineers so that access is restricted to backhoes and/or tracked maintenance equipment and ATVs.

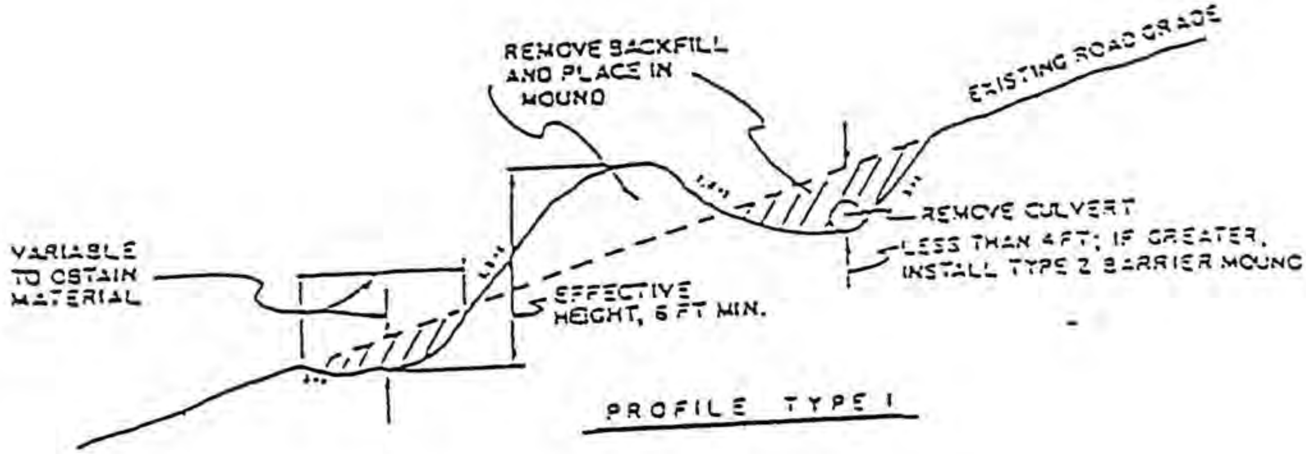
B. Ditches/Culverts

Ditches

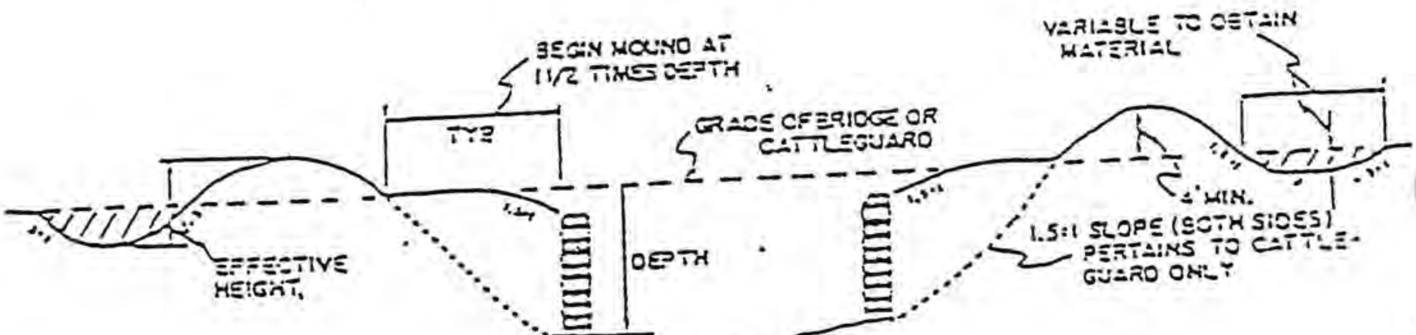
1. Ditches will be allowed to fill in over time and will have no scheduled maintenance except at the Engineer's direction. Ditch water will be handled by cross-ditch and surface water bars as needed.
2. The road will be cross-ditch water barred below every culvert (adequate to handle the water flow the culvert is designed for).
3. Surface water bars will be installed as necessary to control surface erosion and channeling down the roadway.

Culverts

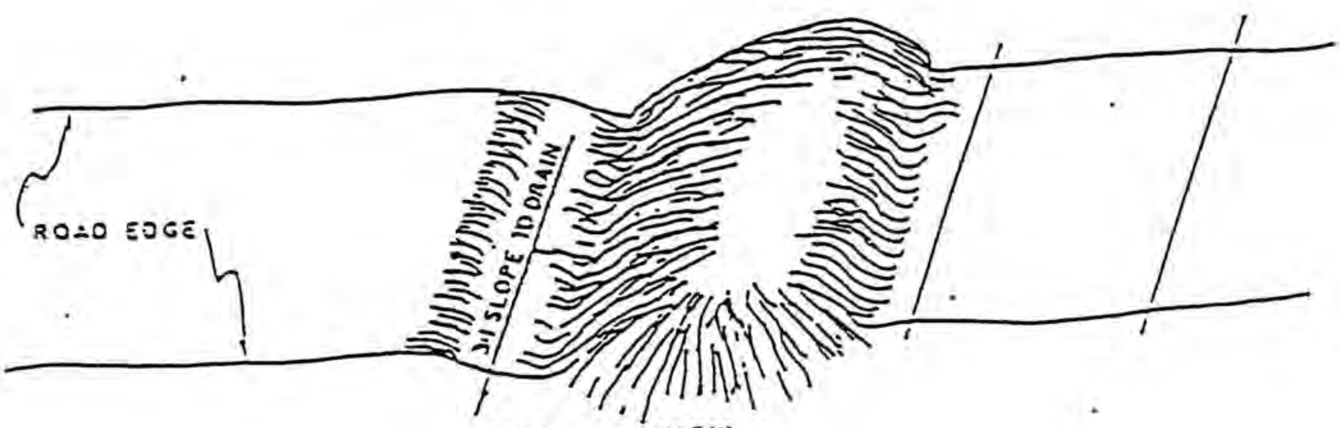
All culverts will remain in place except those determined to be a high risk for plugging because of debris, beavers, or other causes. All culverts remaining are required to have a minimum 90% of the original openings. If a culvert is damaged beyond repair, it will be removed and not replaced unless such removal would restrict maintenance access beyond that point. In that instance, the culvert would be replaced to new road standards for that Road Type (not including rock replacement).



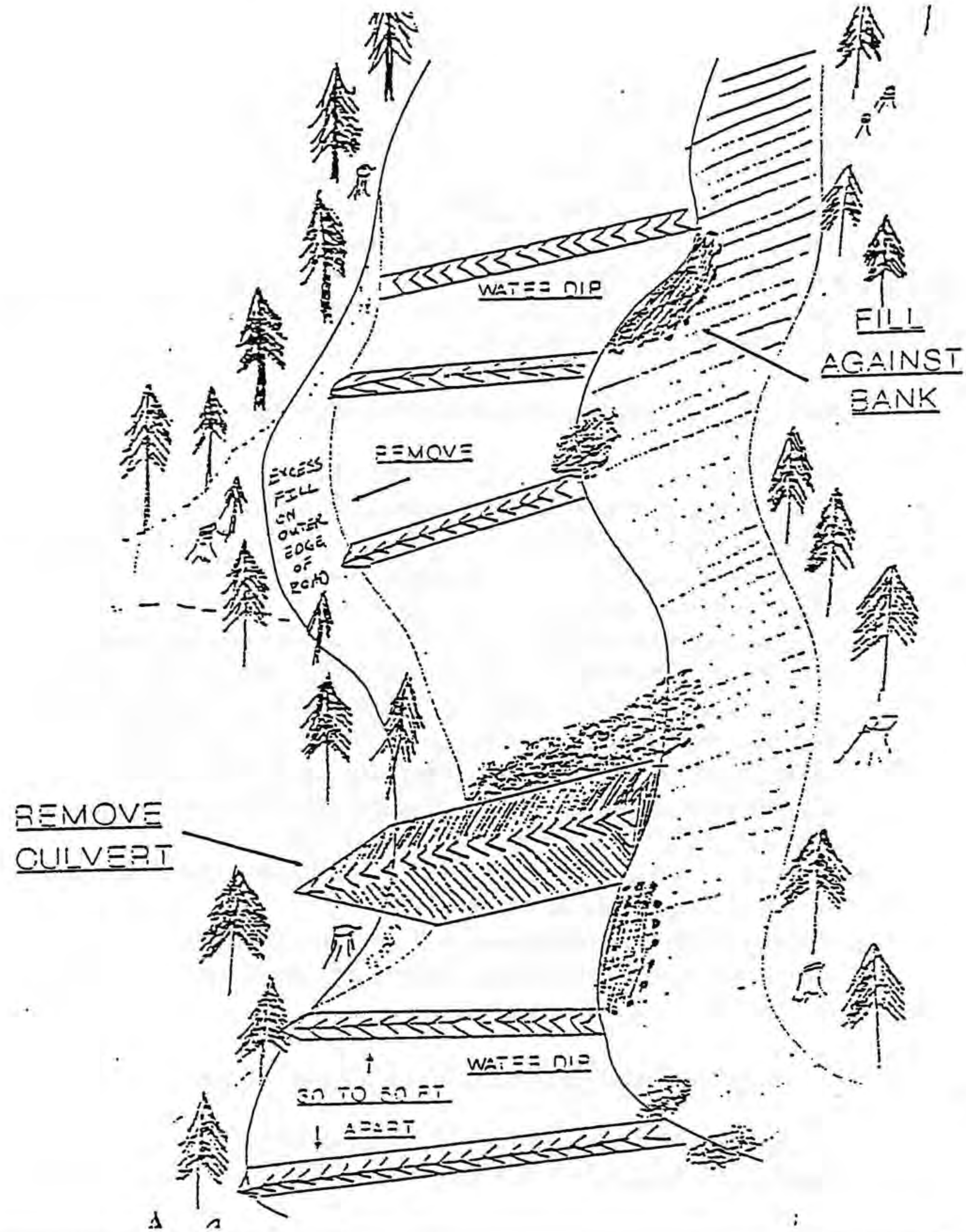
PROFILE TYPE 1



PROFILE TYPE 2



SKETCH VIEW



WATER DIP
FILL AGAINST BANK
REMOVE
EXCESS FILL ON OUTER EDGE OF ROAD
REMOVE CULVERT
WATER DIP
30 TO 50 FT
APART

LEVEL 4 MAINTENANCE (ABANDONMENT)

The goal of Level 4 Maintenance (Abandonment) is to identify and remove from the system those roads that are not expected to be used at the next rotation. These include new roads that are purposely built for a specific logging situation or piece of equipment and will not be needed again, old roads still remaining from prior logging that will not or should not be used, and roads that were built which were never utilized and determined to be unneeded. Roads that will be abandoned will require consultation with State Foresters for approval to remove the road and to end our responsibility for maintaining them. The desired outcome of a road abandonment is to return the road prism to a pre-construction condition in terms of drainage, stability, and suitability for planting.

A. Roads on Ground Less than 60% Side Slope (see diagram)

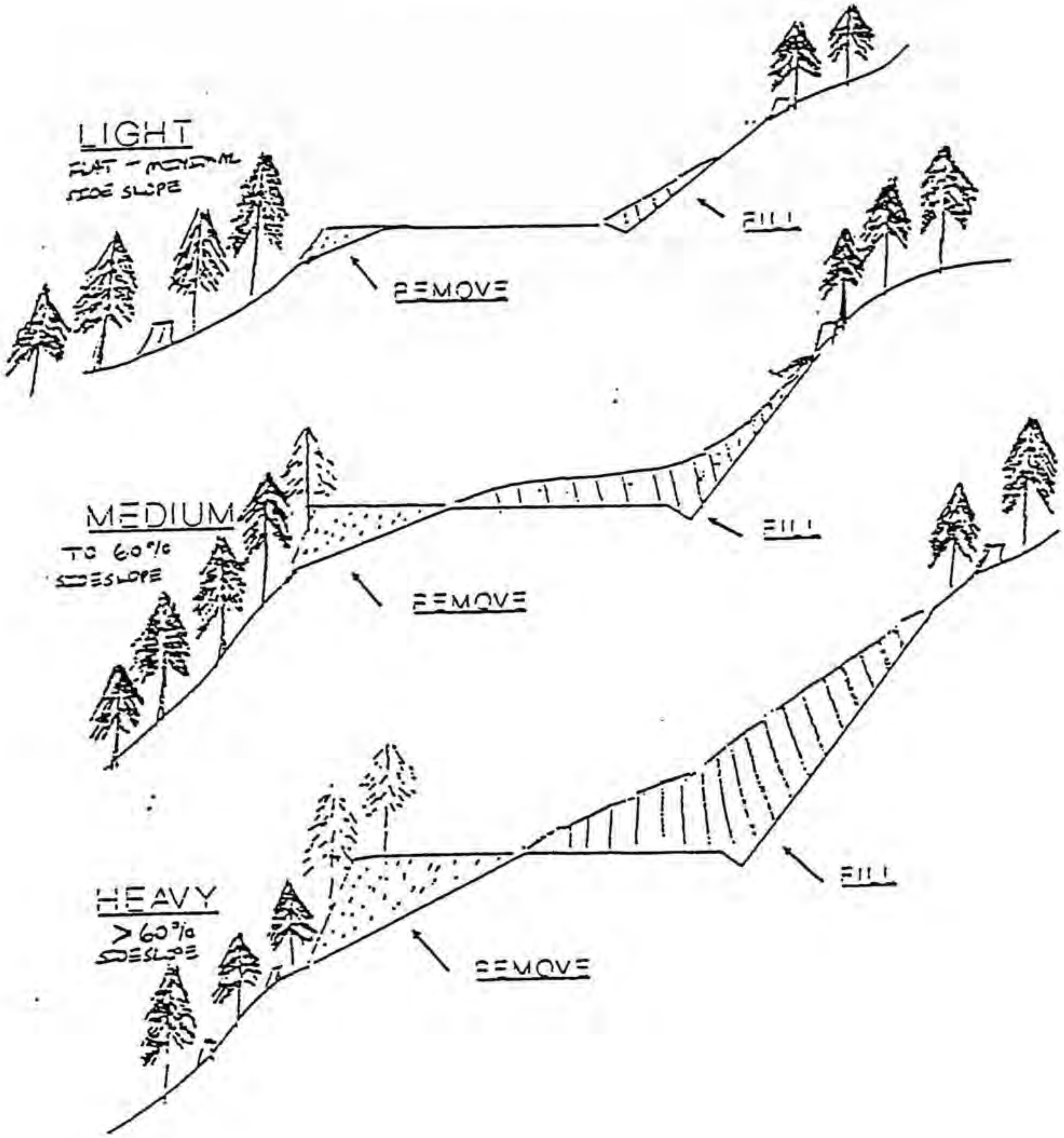
1. Obtain State Forester approval to abandon the road.
2. Remove all culverts and open up drainage's back to natural slopes.
3. Install a cross ditch water bar every 30-50 feet with the interval between water bars decreasing as the road grade increases. The out-fall from the water bar should end on non-erosive materials.
4. Pull back shoulder material, as necessary, to ensure the long-term stability of the road bed. As much as possible, natural re-vegetation on stable cut and fill slopes should not be disturbed. Materials moved and the remaining road bed should be in such condition that if a failure occurs, public resources are likely not to be damaged. Special consideration should be given to areas that adjoin waters of the State, wetlands, or other environmentally- sensitive sites.
5. After all work is completed, the former road will be recognizable as a road but will be in plant-able condition.
6. Roads planned to be abandoned on flatter ground (less than 30% side slope) should be viewed with the opportunity for use as waste sites as possible.

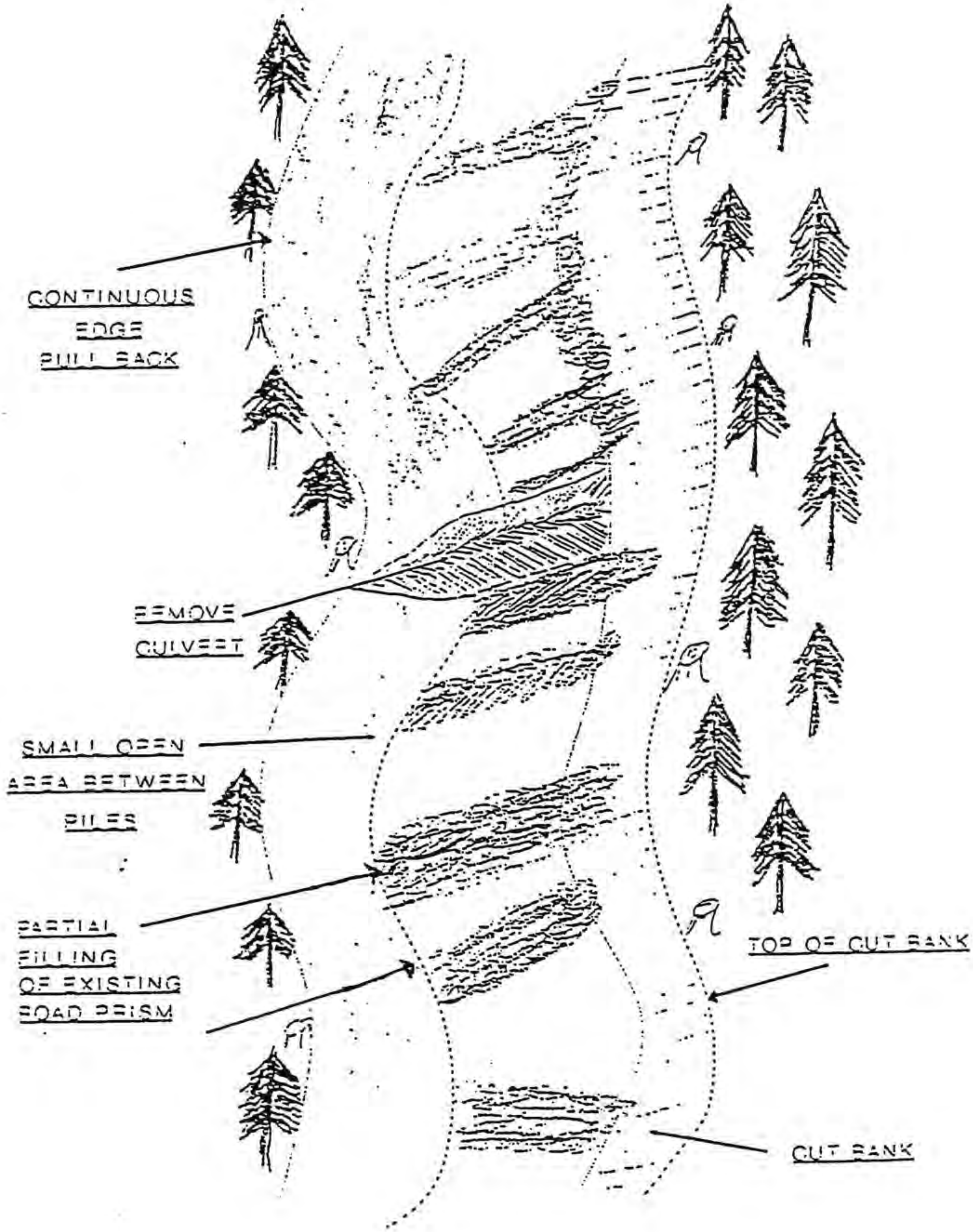
B. Roads on Ground Greater than 60% Side Slope (see diagram)

1. Obtain State Forester approval to abandon the road.
2. Remove all culverts and open up all drainage's back to natural slopes.

3. Install a cross ditch water bar every 30-50 feet with the interval between water bars decreasing as the road grade increases. The out-fall from the water bar should end on non-erosive (stump, rocks, etc.) material. (It is possible that the pull back of side cast materials, as specified in #4 below, may fill up the road prism and negate the need for water bars.)
4. Pull back shoulder material, as necessary, to ensure the long-term stability of the road bed. The road prism will be filled in with this pull back material to match the natural slope, but materials from other sites will not be imported into the site. Materials removed from the fill slope and the remaining road bed should be placed such that if a failure occurs, public resources are likely not be damaged.
5. After all work is completed, the former road may not be recognizable as a road and will generally have the same slope as the adjacent natural ground. The completed project should be in plant-able condition.

ROAD CROSS SECTIONS





ABANDONMENT

Appendix

Road Types (defined)

Road Type	Years (Life)	Standard		Logging Road (Active) Maint. Policy	Forestry Road (Inactive) Maint. Policy
		Drainage	Grade/Rock		
M/L (Primary)	Long-term	Full	to 35 mph max.	1	2
Truck Road (Secondary)	More than 1 unit	Full	to 20 mph max.	1	2
Unit Spurs (Tertiary)	Within 1 unit	Live Water (check post-log status)	to 10 mph max.	1	3/4
Temporary (Planned or Logger Spurs)	1 unit	Minimal (pull out after use)	to 10 mph max.	1	4

Definitions

M/L	All main truck roads, includes paved roads and all designated tie road.
Truck Road	Haul roads that access more than one unit.
Unit Spurs	Planned dead-end roads within a unit that are expected to be used for forestry or future harvest activity.
Temporary	Spurs built that will only be used for one unit and will be ripped and planted after use.
(Active)	Pre-haul, haul, (post-haul depends upon post-logging road status) for all harvest activities as defined in the standards.
(Inactive)	All other roads (including haul roads used during original historical harvest activities).

Road Standards

Double Lane Mainline Road

Sub-Grade

Side Hill Cut	32' (center of ditch to outside shoulder)
Fills	30' (add 2' if fill is over 6')
Compaction	Compact with roller prior to rocking
Turnouts	N/A

Surface

Width	24' running surface (28' toe to toe)
Depth-Crushed	15" compacted
Processing	Roller processed in 4" lifts and water as needed

Single Lane Permanent Rocked Road

Sub-Grade

Side Hill Cut	20' (center of ditch to outside shoulder)
Fills	18' (add 2' if fill is over 6')
Compaction	Compact with roller prior to rocking
Turnouts	10' x 35' plus 10' of taper on each end. Inter-visible to a maximum spacing of 1000'.

Surface

Width	14' running surface (16' toe to toe)
Depth-Crushed	10" compacted
Depth-Pit Run or Jaw Run	15" compacted

Processing

Crushed	Roller processed 4" lifts and water as needed.
Pit Run/Jaw Run	Each load needs to be spread and walked in with the cat.

Single Lane Permanent Dirt Road

Sub-Grade

Side Hill Cut	17' (center of ditch to outside shoulder)
Fills	16' (add 2' if fill is over 6')
Turnouts	10' x 35' plus 10' of taper on each end. Inter-visible to a maximum spacing of 1000'.
Out-sloping	May be used in lieu of ditch where appropriate.

Single Lane Temporary Rocked Road

Two Standards

For larger equipment (particularly rubber-tired) and during wetter months, same as single lane permanent rocked road.

For larger equipment during early summer and early fall and smaller equipment any time (except dirt logging).

Sub-Grade	18' (center of ditch to outside shoulder
Fills	16' (add 2' if fill is over 6')
Compaction	Compact with roller prior to rocking
Turnouts	10'x35' plus 10' taper on each end. Inter-visible to a maximum spacing of 1000'.

Surface

Width	12' running surface (14' toe to toe)
Depth-Crushed	8" compacted
Depth-Pit Run/Jaw Run	12" compacted

Processing

Crushed	Roller processed in 4" lifts and water as needed
Pit Run/Jaw Run	Each load needs to be spread and walked in with the cat.

Temporary Dirt Road

Same as permanent dirt road except sub-grade for side hill cut would be 15', and cut slope should be as steep as conditions allow.

Culverts

Water should be handled at its sources or as near to the source as is environmentally and economically feasible (i.e. the only water in ditches should be from rain runoff).

Ditch Relief — Minimum of 18"
Skewed 30° to center line (unless in low spot)
2 to 6% slope (match slope of ditch up to 6%)
Spacing: Need to fit the soil conditions and give special emphasis to length of ditch feeding into live stream crossings. Try to keep this length less than 150' where feasible and drain onto the forest floor. Goal is to have 200' from the culvert outlet to the stream. Where this isn't feasible, an extra ditch relief culvert may be needed.

Road Gradient	Maximum Spacing
Less than 8%	1000'
8% to 15%	800'
Over 15%	600'

Definite Draws — Designed for 50-year flood, minimum of 24"

The above sub-grade and surface widths do not include curve widening. Cut slopes should be designed to fit the soil type and slope of the ground. Normally, this would be: 1½:1 fill slopes, ¾:1 common (slide slopes 6% or less), ½:1 common (slide slopes greater than 65%) or soft rock, and ¼:1 solid rock. Fills should be compacted in 1- to 2-foot layers, preferably by a roller.

STORM PATROL PLAN

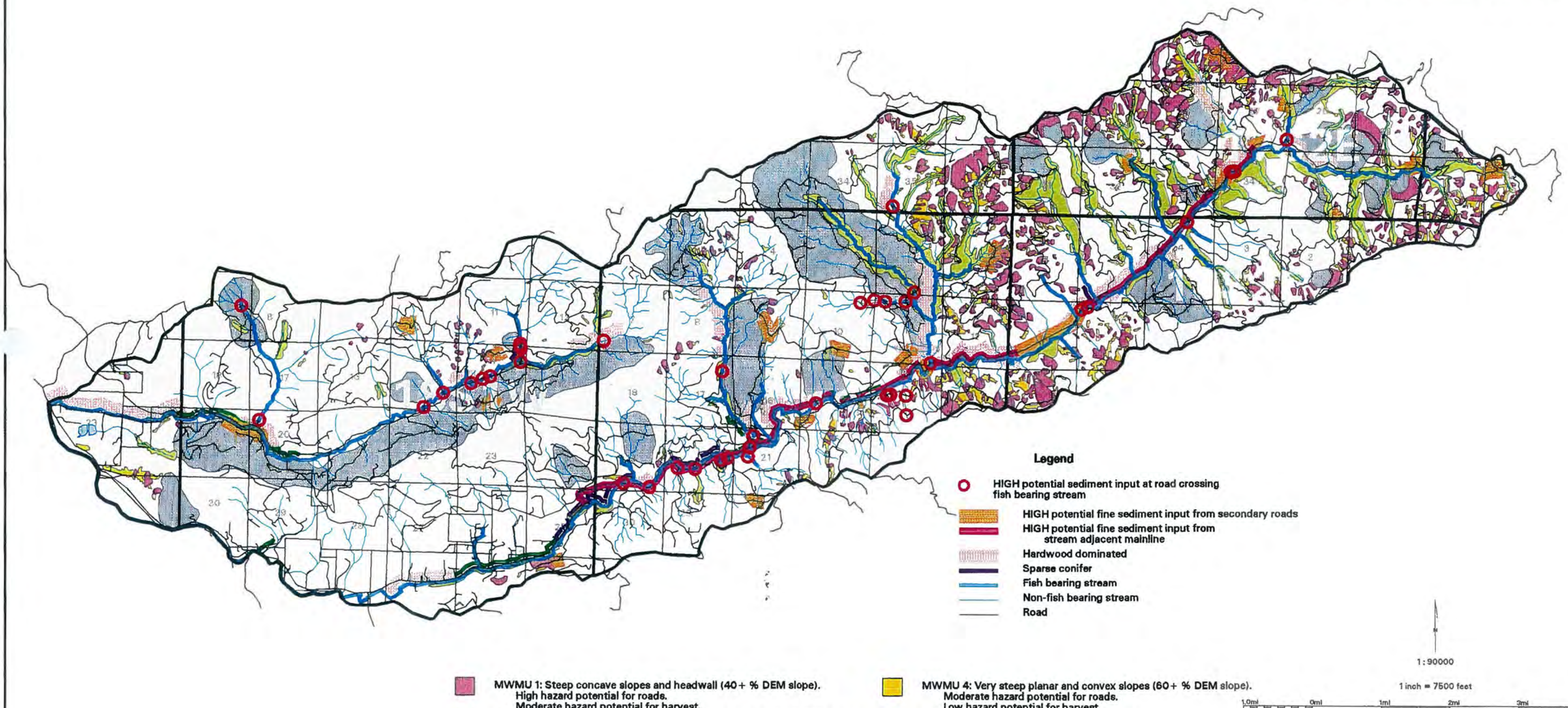
The need for storm patrols will be determined by the team leader or person(s) designated by him. Factors such as snow pack, soil moisture conditions, weather forecasts, inputs from sources internal (watershed team, etc.)and external (State Foresters, etc.), and potential risk (to Company lands and improvements, neighbors downstream, etc.) will be considered before instituting a storm damage patrol. Safety is always the first consideration. If conditions are such that personal safety is an unreasonable risk, the patrols will be delayed until they can be conducted safely.

SPRINGFIELD and COTTAGE GROVE FOREST AREAS

Upon determination of the need for a storm patrol, the Engineers will make a preliminary recon. of conditions and evaluate the extent of resources needed to adequately survey Weyerhaeuser lands for potential problems. The Engineers will coordinate the patrols in cooperation with other team members and contractors, based on knowledge of current operations and potential "hot" spots. Information gathered by the patrols will be routed back through the Engineers for determination of priorities to repair or otherwise deal with the issues discovered.

MAP RX1
PRESCRIPTION SENSITIVITIES

Little Fall Creek/Hills Creek WAU



- MWMU 1: Steep concave slopes and headwall (40+ % DEM slope).
  High hazard potential for roads.
  Moderate hazard potential for harvest.
- MWMU 2: Steep slopes on the margins of inner gorges (40+ % DEM slope).
  Moderate hazard potential for roads.
  Moderate hazard potential for harvest.
- MWMU 3: LPD-prone terrain (30+ % DEM slope).
  Moderate hazard potential for roads.
  Low hazard potential for harvest.
- MWMU 4: Very steep planar and convex slopes (60+ % DEM slope).
  Moderate hazard potential for roads.
  Low hazard potential for harvest.
- MWMU 5: All other areas in the WAU.
  Low hazard potential for both roads and harvest.

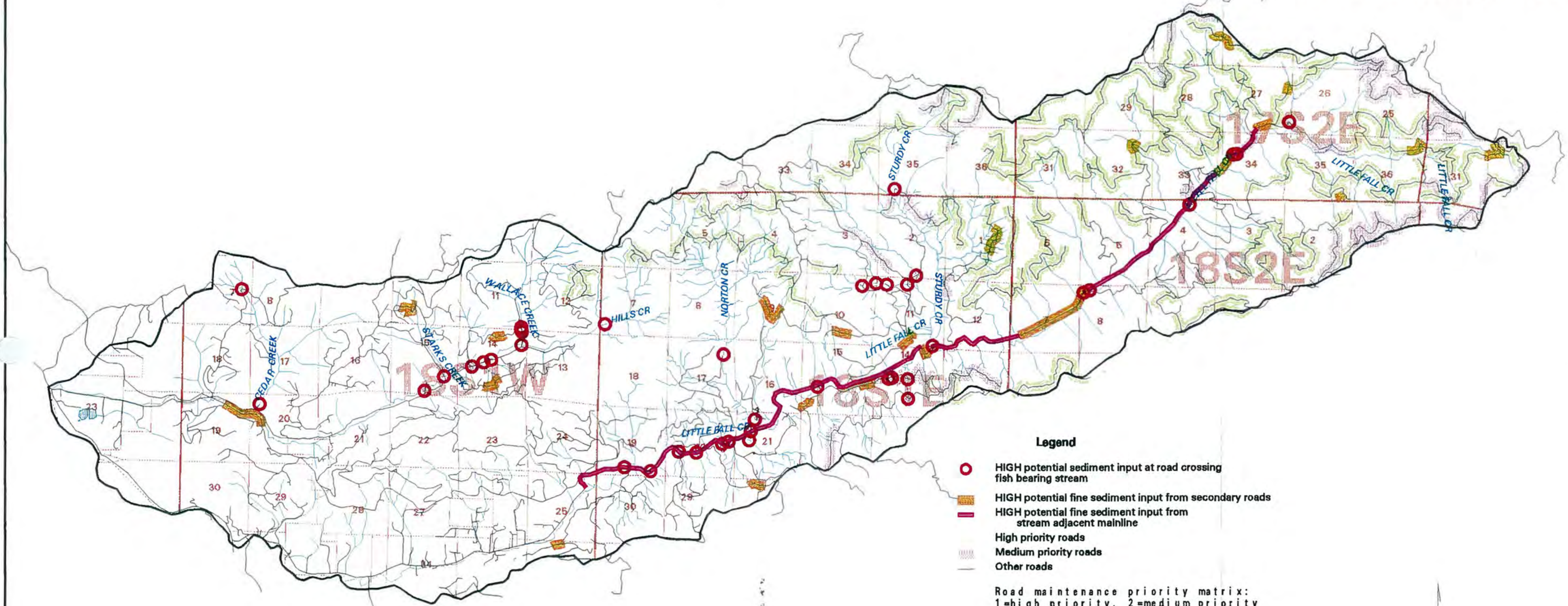
Map RX1 Prescription Sensitivities

Weyerhaeuser

DATE: 05/14/97

MAP RX2
PRESCRIPTION SUMMARY
ROAD MAINTENANCE

Little Fall Creek/Hills Creek WAU



Legend

- HIGH potential sediment input at road crossing fish bearing stream
- HIGH potential fine sediment input from secondary roads
- HIGH potential fine sediment input from stream adjacent mainline
- High priority roads
- Medium priority roads
- Other roads

Road maintenance priority matrix:
1=high priority, 2=medium priority

Slope ------>	>65%	30-65%	<30%
Rain-on-snow	1	1	-
Snow dominated	1	2	-
Rain dominated	2	-	-

1:90000

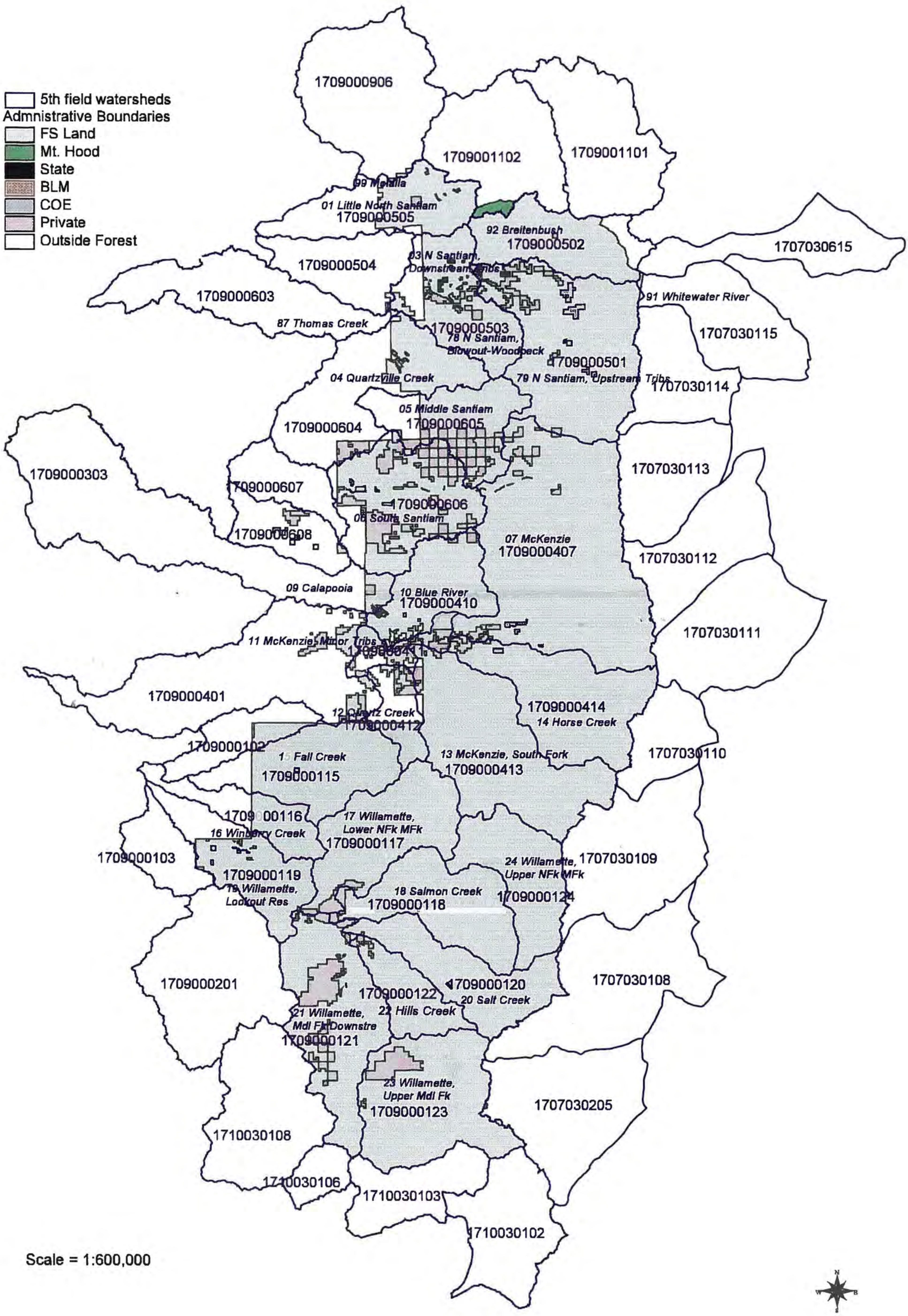
1.0mi 0mi 1mi 2mi 3mi 4mi

Map RX2 Prescription Summary

Weyerhaeuser

DATE: 05/13/97

Administrative Boundaries over 5th Field Watersheds Willamette National Forest



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