Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed

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Executive Summary

This report describes the forest road system in the Kilchis River watershed. This inventory was generally conducted prior to major storms in 1995-96. The objective of this study was to determine the relative potential for forest roads to deliver sediment to the watershed. Roads were then re-inspected to identify landslides and washouts. The study was designed for use in a watershed analysis of sediment delivery for the forested portions of the Kilchis River watershed.

Because of the significant alteration to slopes and channels, roads, rather than timber management, are the primary source of sediment from forest management activities in the west (Megahan and Ketcheson, 1996). There are two ways to mitigate sediment delivery to streams: 1) reduce the volume of erosion through on-site control practices; and 2) reduce sediment delivery by increasing sediment retention on the hillside (Megahan and Ketcheson, 1996).

Because of the high potential for sediment delivery to streams, many forestry best management practices deal with road construction and maintenance. A "best management practice" is a practice or combination of practices that, after problem assessment, examination of alternative practices and public participation is determined to be the most effective and practicable means of preventing or reducing non-point source pollution to a level compatible with water quality goals. The State of Oregon regulates forest road construction and maintenance through the forest practice rules.

Research conducted over the last 40 years in the Pacific Northwest has investigated ditch erosion, condition of drainage structures, surface erosion, hillslope erosion, landslides, sediment travel and delivery, turbidity, and sediment budgets as related to forest roads. Over the period of this research, there have been major changes in accepted road management practices, and also major differences in year to year climate. Geology and soils also vary tremendously around the region. Therefore, quantitative results of any one study may have only very limited applicability to roads in the Kilchis River Watershed.

Most of the forest roads in the basin were constructed between about 1920 (old railroad grades) and 1970. Roads have also been constructed over the past twenty years in the lower third (unburned) portions of the basin. A large but unknown percent of the old roads have been abandoned, and are no longer driveable or easily identified as roads.

Every "official" forest road (those used for forest management purposes since 1972) in the Kilchis watershed, or with drainage directed to the Kilchis watershed, was driven or walked to collect the necessary data. The field survey gathered information on: 1) General road characteristics; 2) The condition of surveyed roads in locations where sediment is generated (between discharge locations); and 3) Specific locations of surface water discharges, including potential for sediment delivery to waters.

This survey evaluated 106.7 miles of forest roads in the Kilchis River Watershed. Twenty five percent of road segment length in the basin clearly delivered (flow and any sediment carried by the flow) to streams, while an additional 14 percent were given a possible delivery rating a total of 25 to 39 percent delivery to channels.

A total of 57 landslides associated with the storms of 1995 and 1996 were identified. Forty-eight of the road or landing associated landslides that occurred during the winter of 1995-96 in the Kilchis watershed involved more than ten cubic yards of material. In addition, there were twenty-two washouts which eroded greater than ten cubic yards of material, and there were at least another twenty-eight washouts of less than ten cubic yards volume.

The percentage of the road system delivering sediment to streams in the Kilchis watershed (between 25 and 39 percent) was lower than the 57.3 percent reported by Wemple (1994) or the 75 percent reported by Reid and Dunne (1984). It was comparable with the 34 percent reported by Bilby and others (1989). It was exactly the same as the western Oregon random survey (Oregon Department of Forestry, 1996). Average segment lengths from stream crossings to the first cross drainages above the stream crossings was 436 feet, while average spacing for the entire road system was 381 feet. This suggests that roads are designed and maintained for efficient delivery of water to channels. This is in contrast to the current forest practices rules, which require filtering of muddy runoff water through the forest floor.

At the present time, the two principal surface erosion concerns in the Kilchis basin are:

1. Excessive length of ditch routed to deliver sediment directly to channels; and

2. Steep gradient roads (over 13 percent) with excessively spaced cross-drainage structures.

Landslides and washouts are clearly the dominant erosional process associated with forest roads in the Kilchis watershed, especially in years when there are major storms. Analysis of the road-related landslides data will be conducted with the historical landslides analysis of the Kilchis watershed, and will be compared with the Wilson River Storm of 1996 monitoring study site, as well.

As part of this study and a similar study conducted over all of western Oregon, a road inventory protocol was developed for forest land managers use and to provide information needed in order to prioritize road management decisions, especially maintenance and repair activities. It is intended for priority use in areas where roads pose higher risks to anadromous fish and their habitats. This report also includes several specific recommendations for road managers in the Kilchis watershed.

Acknowledgements

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Dr. Arne Skaugset, Assistant Professor of Forest Hydrology at Oregon State University, coordinated protocol development and managed the project. The field surveys were conducted by Kami Ellingson, Keith Martin, Ruth Willis, and Steven Schmidt. Special thanks go to Kami for her diligent efforts in making the global positioning system and in helping prepare this report. Data analysis was performed in large part by Keith Martin.

Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed

Introduction

This report describes the forest road system in the Kilchis River watershed. All official forest roads in the watershed were inspected on site. For this study, a forest road is any road that has been used for forest management activities since 1972 (the legal interpretation recognized by the Oregon Forest Practices Act). This survey did not include roads abandoned before 1972. There are many miles of abandoned road grades in the Kilchis watershed.

Road system elements that either produce or control sediment delivery were measured or categorized. This inventory was generally conducted in the summer of 1995, prior to major storms the following winter. The objective of this study was to determine the relative potential for forest roads to deliver sediment to the watershed. These roads were re-inspected during the summer of 1996 to identify landslides, washouts and conditions associated with this damage.

The study was designed for use in a watershed analysis of sediment delivery for the forested portions of the Kilchis River watershed. This report will provide information relevant to two of the three goals of the Tillamook Bay National Estuary Project, which are to: "protect and enhance anadromous fish habitat" and "restore the bay from the impacts of sedimentation." This study is intended to compliment a historical analysis of landslides in the Kilchis watershed (in progress).

Figure 1. Typical Cross-Section (Prism) of a Forest Road.

Roads, Erosion, and Sediment Delivery

Roads create a contiguous linear physical alteration to hillslopes, as shown in Figure 1. To create the running surface, or tread, it is necessary to excavate into the natural hillslope. Normally this excavated material is used as fill, to make a portion of the running surface. Both cut and fillslopes steeper than the natural slopes, and, at least for some period of time after construction, are unvegetated. Cut and fill slopes have a higher erosion potential than the native hillslopes, both because of the steeper slope and because of the exposed, relatively loose soil. On steeper hillslopes the risk of mass erosion (landslides) from roads is also elevated.

Roads also alter the flow of water. Road cuts may intercept groundwater, and the road surface normally collects surface water. This water is routed down the road to a location where it is discharged away from the road. Roads must also cross streams. Most stream crossing structures are culverts. During high flows, stream flows can exceed culvert capacity. When culvert capacity is exceeded, fill washout or channel diversion may occur. Drainage waters remove eroded sediments from the roadway, and sometimes into streams.

Traffic on gravel surface roads also increases the potential for sediment delivery to streams. Reid and Dunne (1984) found that sediment yield from road surfaces in western Washington on actively used logging roads was 1000 times that of the yield from abandoned roads, and up to 500 tons/kilometer. However, a separate study found that sediment yield from secondary roads was 10 tons per kilometer of road, while for active roads it was 26 tons per kilometer (Bilby and others, 1989). This is an order of magnitude difference from Reid and Dunne (1984), even though the studies were conducted on areas of similar geology and climate. Sediment delivery to streams is extremely variable, depending on traffic levels, quality of road surfacing, climate, drainage design, maintenance practices, and other factors.

Road Management Practices

Because of the significant alteration to slopes and channels, roads, rather than timber management, are the primary source of sediment from forest management activities in the west (Megahan and Ketcheson, 1996). There are two ways to mitigate sediment delivery to streams: 1) reduce the volume of erosion through on-site control practices; and 2) reduce sediment delivery by increasing sediment retention on the hillside (Megahan and Ketcheson, 1996).

Because of the high potential for sediment delivery to streams, many forestry best management practices deal with road construction and maintenance. A "best management practice" is a practice or combination of practices that, after problem assessment, examination of alternative practices and public participation is determined to be the most effective and practicable means of preventing or reducing non-point source pollution to a level compatible with water quality goals.

The State of Oregon regulates forest road construction and maintenance through administration of forest practice rules. These rules address the following topics: activities requiring prior approval by the State Forester; road location; design of the road prism, stream crossing structures, drainage structures, and waste disposal areas; construction practices including disposal of waste, drainage stream protection and stabilization; development, use and abandonment of rock pits and quarries; road maintenance; and vacating forest roads. Applicable rules are found in OAR 629-625-000 through 629-625-650, and are included as Appendix 1. Specific practices required under these rules include: road location away from streams, the steepest slopes, and unstable areas; cut and fill slopes designed at generally stable angles; design of stream crossing structures for the 50-year flow with no ponding behind the fill; control, dispersion, and filtering of drainage waters; revegetation and stabilization of exposed soil; and maintenance of the road surface and drainage structures.

Studies on Road Erosion

Research conducted over the last 40 years in the Pacific Northwest has investigated ditch erosion, condition of drainage structures, surface erosion, hillslope erosion, landslides, sediment travel and delivery, turbidity, and sediment budgets as related to forest roads. Over the period of this research, there have been major changes in accepted road management practices, and also periods of major storms, and relative periods of climatic calm (storms drive much of the potential for erosion from roadways). Geology and soils also vary tremendously around the region. Therefore, quantitative results of any one study may have only very limited applicability to roads in the Kilchis River Watershed.

Ditch erosion was the major factor used to recommend culvert spacing in guidelines developed for the USDA Forest Service (Arnold, 1957). These guidelines were developed based on experience with roads in the Cascade Mountains. Piehl and others (1988) evaluated ditch relief culverts in the central Coast Range (Lincoln to Coos Counties) and compared culvert spacing to that recommended by Arnold (1957). The Piehl study found that actual culvert spacing averaged 1.7 times that recommended by Arnold (1957), and also found average outlet erosion of $0.7 m^3$ associated with each ditch relief culvert (excluding two landslides which together resulted in twice the erosion volume of all the surface erosion combined).

Generalized surface erosion from roads has been evaluated by many studies (Bilby and others, 1989; Burroughs and King, 1989; Ketcheson and Megahan, 1996). These studies found that most surface erosion from forest roads occurs in the first year or few years after construction (Ketcheson and Megahan, 1996). Sediment production from roads is extremely variable, depending in part on local climate, soils, geology, landform, and relative disturbance by the road of the hillslope and channels. Even within a single study location, in one case the southwest Idaho batholith, researchers found from 6 to 49.5 m^3/ha/yr on average, and from 1.9 to 149.9 m^3/ha/yr over the four years of the study (Ketcheson and Megahan, 1996).

Most of the studies which have evaluated sediment production from roads have taken place during periods of normal precipitation. How estimates of sediment production from other regions conducted during more typical weather relate to the Kilchis River is unclear, especially when considering the extreme storms of November 1995 and February 1996. Large, infrequent storms tend to produce landslides and washouts. It is generally not possible to reliably sample sediment movement associated with landslides and washouts during such large storms. Erosion volumes from landslides and washouts are generally based on site-specific measurements which estimate dimensions of the remaining void.

An ongoing study is investigating surface erosion from forest roads in the central Oregon Coast Range west of Eugene. (Black, T. Personnel Communication, 1997) In this study, segments of road were carefully selected to evaluate the influence of basic road design parameters on sediment production. Sediment production was measured using concrete inlet structures which routed all sediment into large plastic bins (sediment traps). For most of the sample plots in this study, cutslopes were cleared of vegetation. This was done in order to reflect conditions more typical of new roads. Preliminary results found sediment production to be less than expected, at least based on the results of other studies. Average sediment production varied from 50 killograms (kg) for untreated roads, and 377 kg for roads with disturbed cutslope and ditch (plots were 40 to 110 meters in length). Plots with coarser soil produced about 9 times less sediment than plots where soils were relatively fine-grained.

Prevention of eroded material delivery to streams is the main objective of most best management practices. Eroded materials can be transported to streams or hillslopes. The volume of erosion and obstructions on the hillside have the greatest influence on sediment travel below all points of discharge, while hillside steepness and runoff source area also affect sediment travel distances below culverts (Megahan and Ketcheson, 1996). Bilby and others (1984) concluded that the most effective and least costly approach to stream protection was to drain ditches onto the forest floor. Forest soils of the Pacific Northwest typically have very high infiltration rates. When muddy runoff is diverted onto uncompacted soils, water flows into the soil, leaving the sediment on the hillslope. This process ceases when soils become saturated and overland flow occurs. The more water directed onto the hillslope, the more likely overland flow will occur.

Only a portion of material eroded from the road prism enters streams. The remaining materials are stored somewhere in the road prism, or on hillslopes below the roadway. Sediment delivery to streams depends on the percentage of the road drainage system discharging directly into streams; the proximity of non-stream discharges to channels; the volume of water and the potential for gully development (stream extension); and the volume of eroded material available. Reid and Dunne (1984) found that 75% of road drainage in their western Washington study site was discharged directly to streams, while Bilby and others (1989) found that 34% of road drainage points flowed directly to the channel. Wemple (1994) found that 57.3% of road drainage in the Blue River area of the western Cascades, Oregon, delivered either to channels or gullies.

The major concern with sediment is its effects on streams and water quality. Stream effects include possible increase in fine sediment deposition in gravel (used for fish spawning; increased water turbidity; and downstream channel aggradation and associated changes in channel morphology. Oregon has a state water quality standard for turbidity and a general anti-degradation policy that applies to the other water quality and channel effects.

Bilby and others (1989) found that 21% of the annual sediment load at their study site was due to road erosion. They also found peak turbidity below the road of 110 nephelometric turbidity units (NTU) and of 40 NTU above the road. Additionally, most sediment was fine (typically very grained silts which generally moved through the channel system without significant deposition). Turbidity is an extremely variable parameter, and normally cannot be directly related to sediment loading (Anderson and Potts, 1987).

Landslides and washouts are generally the most dramatic means by which road sediments are delivered to streams. Landslides are movements where shear failure occurs on a surface or combination of surfaces, and a mass of soil, rock and/or debris (rather than a particle) moves downslope. Washouts are fluvial processes where streamflows either overtop fills or are diverted down roads, resulting in significant erosion of the roadway and high sediment delivery to channels.

In areas with steep slopes, landslides are the dominant erosional mechanism. Landslide frequency can be greatly accelerated by road management practices (Sidle and others, 1985). Megahan and Kidd (1972) found that 70% of accelerated sediment production in an Idaho batholith study site was associated with road related landslides. Piehl and others (1988) identified that only 2 landslides at culvert outlets comprised 72% of the total outlet erosion associated with 515 cross-drainage culverts.

Road construction on steep slopes requires significant excavation into and further steepening of these slopes. For traditional road construction, excavated material is used as a fill to make the outside edge of the roadway. The resulting cut and hillslopes are always, by simple geometry, steeper than the original, natural slope. With other factors being equal, the steeper the slope, the lower the relative stability. Therefore, some increase in landslides is the obvious outcome.

The location of landslide occurrence has a tremendous influence on potential sediment delivery to streams. Landslides affecting the cutslope portion of the road are typically deposited in the road. Cutslope landslides may be eroded by road surface waters, or may divert surface waters away from designed drainage structures. Failures of the fillslope, however, are more likely to become debris flows, increasing in size and then entering channels. Almost all major (delivering sediment to streams) road-related landslides investigated by Oregon Department of Forestry are related to road fills or road sidecast

(Mills, 1991). Sidecast is a term used to describe uncompacted excavated fill material pushed on the downhill side of the road, and not designed to be part of the running surface.

Current regulations (OAR 629-625-310(2)) and others prohibit sidecasting to the extent that landslides and channel damage are likely. A technique known as end-hauling is used to transport excess excavated materials to more stable locations. Using steeper grades to keep roads on ridgetops is a far less expensive road construction technique than end-hauling, and is also effective at landslide prevention. However, where this is not possible, end-hauling has been shown to be an effective, albeit expensive, technique for reducing landslides (Sessions and others, 1987). Regulations for end-hauling have been in place since 1983. However, most existing roads, especially those in the "Tillamook Burn" were constructed prior to 1983, when sidecasting was the common construction practice.

In 1990, a major storm occurred in the Deschutes River basin in western Washington. A road damage inventory conducted after that storm found that roads constructed in the last 15 years survived the storm with minimal damage, while roads constructed earlier had very high damage rates (Toth, 1991). Department of Forestry landslide monitoring has made similar findings (Mills, 1991). Therefore, although most surface erosion tends to occur in the first few years after construction or during periods of heavy traffic use, landslides can occur many decades after original construction.

Department of Forestry monitoring has also found that road drainage is associated with about one-third of the investigated road-related landslides (Mills, 1991). Culverts were associated with 29 percent of the damage sites in the Deschutes River study (Toth, 1991). Concentration of road drainage can also be associated with integration of road networks and channels in steep terrain, sometimes resulting in landslides (Montgomery, 1994).

Culverted stream crossings are subject to plugging and/or capacity being exceeded by high flows. If water backs up and flows over the surface, a washout type failure similar to a dam breaching may occur. When roads climb through the stream crossing, there may be a high potential for channel diversion down the road (Weaver and Hagans, 1994). Such diversions can cause large gullies running long distances down the road, and can cause additional landslide and washouts as well.

Watershed Description

The area of study includes all forest lands within the Kilchis River watershed, and also those roads adjacent to the watershed which discharge drainage waters to the Kilchis basin. The Kilchis watershed is approximately 47,000 acres. It is located in the northern Oregon Coast Range. The Kilchis River flows into Tillamook Bay near the town of Bay City. Figure 2 locates the Kilchis watershed in relation to the Tillamook Bay and major streams.

The Kilchis basin is in the Coast Range georegion (ODF, 1997). Hillslopes are typically very steep (60% to over 100%), except near larger valleys and on scattered bench type landforms. Geologic units are dominated by subaerial and submarine flow basalts, with some intrusive rocks, and fine grained sedimentary rocks near the bay (Wells and others, 1994). Rocks are highly sheared and often deeply weathered. Soils are typically shallow and non-cohesive.

Figure 2. Study Area Watershed and Location of ODF "Tillamook" 1996 Storm Study Site.

Average annual precipitation varies from under 100 inches in lowlands near the bay to about 180 inches (Taylor, 1993). Major winter storms occurred over this area during November 1995 and February 1996. The November storm was of short duration, less than 24 hours, and was most intense in an area between 3 and 8 miles inland from Tillamook Bay. The February storm lasted four days, and the most severe impacts occurred 12 to 20 miles inland from the bay (generally east of the Kilchis watershed) and produced upwards of 20 combined inches of combined rainfall-snowmelt in many locations during this time period.

Most of the forest roads in the basin were constructed between about 1920 (old railroad grades) and 1970. Roads have also been constructed over the past twenty years in the lower third (unburned) portions of the basin. A large but unknown percent of the old roads have been abandoned, and are no longer driveable or easily identified as roads.

Fires played a major role in the erosional processes and management of the upper 2/3 of the Kilchis watershed. The 1918 Cedar Butte Fire and the 1933, 1939 and 1945 Tillamook fires all burned in portions of the upper 2/3 of the basin. Salvage logging of burned timber in the Kilchis watershed began in the 1950s and continued through the 1970s.

Methods

Development and Testing

Oregon Department of Forestry's Forest Practices staff initiated a process to scope potential approaches for monitoring forest road sediment BMPs in 1993. Forest Practices staff worked closely with the Forest Engineering Department at Oregon State University. The monitoring protocol was developed with input from forest landowners, agency personnel, and other interested landowners. This protocol was field tested on 18 miles of forest roads in northwest Oregon during 1994.

Surface Erosion and Delivery Methods

Every open forest road in the Kilchis watershed, or with drainage directed to the Kilchis watershed, was driven or walked to collect the necessary data. When possible, a global positioning system (GPS) was used to identify locations of drainage discharge. The field survey gathered information on: 1) General road characteristics;
2) The condition of surveyed roads in locations where sediment is generated (between discharge locations); and 3) Specific locations of surface water discharges, including potential for sediment delivery to waters.

General characteristics

The survey collected the following data to describe the overall road:

1. Legal location (section; township; range) and name;
2. Forest practices maintenance status (active, inactive, or vacated); and
3. Road surfacing material (clean rock, dirty rock, or dirt).

A typical length of road is shown in Figure 3, which illustrates some of the road characteristics investigated during this study.

Source area

The source area is the length of road draining to any one location. Data were gathered for every segment of road in the survey area. Information collected was designated to evaluate the potential for erosion (sediments generation). Data were collected to describe:

1. The length and average slope of each road segment;
2. Road surface shape (crown, inslope, outslope);
3. The condition of the ditch;
4. Height and vegetative cover of the cutslope; and
5. The presence of landslides or active erosion site.

Figure 3. Typical length of road near a stream showing most elements of the surface erosion-drainage inventory. A: Cross-drainage culvert with sediment filtering B: Stream crossing culvert C: Ditch D;E: Cutslopes F: Stream crossing fill
Numbers are segments, or portions of segments.

Discharge

Locations of discharges from the road surface included cross-drainage culverts; live stream crossings; waterbars; rolling dips; grade reversals; natural saddles; and random points of discharge. The survey collected information on drainage characteristics and potential sediment delivery at all locations of discharge.

The diameters of all cross drainage and live stream crossing culverts were measured. The condition of the culvert inlet was gaged by estimating what percentage of original culvert area was open. When effective inlet opening was reduced, the principal cause was recorded (mechanical crushing, filling by debris, or age related deterioration).

The outlet or discharge point was evaluated for evidence of flow (delivery) to a waterbody. Discharge directly into a stream was given a "yes" rating for delivery, as was a location which discharged into a gully and that gully entered a channel. Locations with either no erosion or deposition immediately below the discharge or with minor erosion for a short, well-defined distance and also with a large flat area for deposition were given a "no" sediment delivery rating. All other locations were given a "possible" delivery rating.

Data collection

Data were collected on site in the field using either a distance measuring instrument (DMI) which records vehicle travel in feet or a hip chain for distance measurements. Slope measurements were made using a clinometer, interpolating average road grade between discharge points when actual road grade was not constant. Data were collected by two student workers under geotechnical specialist supervision. Road surveys were done during the summer of 1995. Information was directly entered into a personal computer and a relational database.

Originally, this study was to include limited sampling of sediment movement through discharge structures. This element of the study was eliminated after the storms, since much fine material may have been eroded from the roads, and also because the storm created a unique opportunity to compare road drainage with major storm impacts (landslides and washouts).

Landslides and Washouts Re-Survey

All forest roads in the Kilchis watershed were resurveyed during the summer and early fall of 1996 (after the major storms). Road-related landslides and fill washouts were located and mapped. The mode of failures and impacts to the roads were described. Lengths, widths, and depths of the original failure masses were measured. Conditions of the roads including percent of bench and fill, width before and after failure, fill depth at the shoulder, cutslope height, and any other drainage features were described. Geomorphic conditions, including the hillslope steepness above and below the failure were measured. A description of the dominant vegetation, significant wood in the road fill, presence of large amounts of slash, soil type, and delivery to streams are also included in the database.

Concurrent Oregon Department of Forestry Studies

Three studies of relevance to the Kilchis road erosion studies are currently underway. A historical analysis of landslides in the Kilchis watershed is being conducted using aerial photographs and is partially completed. A road erosion study of randomly selected roads throughout western Oregon has just been completed (ODF, 1996).

The final study is a comprehensive assessment of landslide and channel impacts which occurred during the February 1996 storm at six locations within the storm impacted area of western Oregon. The Storm of 1996 study included an on-the-ground survey of every channel in the study sites, to identify all landslides which entered channels, and the impacts associated with those landslides. One of these "Storm of 1996" study sites is located in the Wilson River watershed (five to ten miles east of the Kilchis watershed). This area has similar geology, landforms, and soils to those found in the Kilchis watershed. This "Tillamook" study site is shown in Figure 2.

An area of 7.75 square miles in the North Fork Wilson River Watershed was surveyed for landslides and channel impacts during the summer of 1996. A total of 70 landslides which entered channels were identified during this survey. Approximately 75 percent of the channels in the study site had "high"impacts (typical of debris torrent scour). Of these 70 landslides, 8 were related to active roads, and 15 were associated with abandoned roads and skid roads. The remaining 47 landslides occurred in 30 to 50 year old forests where there was no evidence of physical slope alterations. Total volume of sediment moved by these landslides (initial slope failure and volume of debris flow added) were as follows:

Active road landslides	32,408 cubic yards	41 %
Abandoned road landslides	15,720 cubic yards	20 %
Non-road related landslides	30,416 cubic yards	39 %
Total landslide volume	78,544 cubic yards	100 %

Results

All "open" roads in the Kilchis watershed were surveyed using this protocol. Most of the surveying was conducted during the summer of 1995, with some resurvey work done in 1996 to fill in data gaps. In addition, all roads were re-inspected in 1996 to locate and describe landslides and washouts which occurred during the winter of 1995-96.

There are 563,350 feet of "open" forest roads in the Kilchis River Watershed (106.7 miles). Ninety-five percent of the these roads were classified as inactive (no log hauling), and 96 percent were rocked (dirty rock classification). Fifty-three percent of the roads were classified as midslope, 25% as valley bottom, and 22% as ridgetop.

Drainage Discharges

Every location where collected water flowed off or under the road (drainage discharges) was identified and surveyed. The most common type of drainage was a waterbar (21%), followed by stream crossing culverts (19%) and cross-drain culverts (16%) (Table 1). Non-engineered (random) relief made up 16 percent of the drainage points. There are 18 bridges on forest roads in the Kilchis watershed. A total of 1,202 distinct discharge points were evaluated by this survey.

Twenty five percent of road segment length in the basin clearly delivered (flow and any sediment carried by the flow) to streams, while an additional 14 percent were given a possible delivery rating for the total of 39 percent as shown in Table 1.

Table 1. Summary Statistics for Drainage Discharge Points and Segment Lengths (all lengths in feet). [Entire survey, and that portion of survey with obvious delivery to channels.]

	Entire Kilchis Data Base					Positive Delivery to Channels				
	Discharge Points		Discharge Length			Discharge Points		Discharge Length		
Description	# of	Percent	Length	Percent	n	# of	Percent	Length	Percent	# Seg.
Cross-Drain Culvert	197	16	122731	22	228	78	40	52365	43	95
Live Stream Culvert	224	19	106508	19	255	224	100	106508	98	255
Bridge	18	1	12352	2	29	18	100	12287	99	29
Ditch Relief	49	4	28851	5	53	7	14	3503	12	8
Water Bar	252	21	87060	15	259	56	22	17524	20	57
Saddle	10	1	7907	1	14	0	0	0	0	0
Grade Break*	181	15	79381	14	344	10	6	3485	4	19
Other	22	2	11275	2	25	5	23	2781	25	6
Road Junction	62	5	29744	5	62	10	16	3318	11	10
Non-engineered Relief	187	16	77541	14	209	51	27	17986	23	54
Total =	**1202**	**100**	**563350**	**100**	**1478**	**459**	**38**	**219757**	**39**	**532**

Culvert Condition

The condition of a culvert inlet has a potentially large influence on the ability of that culvert to pass drainage water, especially during high flow periods. When surveyed, 67% of the stream crossing culverts and 47% of the cross-drainage culverts were fully open. On the other extreme, 5 percent of the stream crossing and 10 percent of the cross-drainage culverts had inlet openings reduced by at least 50 percent of the original openings. Twenty-nine percent of the cross-drain pipes were at least partially blocked by sediment, while 11 percent of the stream crossing pipes were affected by sediment. Mechanical crushing affected 19 percent of the cross drains and 9 percent of the stream crossings. Table 2 summarizes culvert inlet openings as a percent of original pipe cross-sectional area on all measured culverts (stream crossings (CSX) and cross drains (XRD) in the

Kilchis basin. (About 20 structures could not be reliably measured for various reasons.)

Road Segments and Drainage Routing to Channels

A segment is defined as a length of road where water is directed toward a single discharge point. This is the road length that can deliver eroded materials to that discharge point. (This can change if discharge structures cease to function and water flows past the discharge point.)

A total of 1,478 distinct road segments were identified in the Kilchis watershed. The average length of these segments was 380 feet. Maximum segment spacing was 2,310 feet. Table 3 summarizes spacing by gradient. Most of the road segments (702) were in the 0-4 percent gradient class, while 98 segments had slopes of 18% or greater (very steep roads).

Table 2. Culvert inlet opening as a percent of original cross-sectional area.

	Stream Crossing Culverts		Cross-Drainage Culverts	
% Open	**#**	**%**	**#**	**%**
100	141	67	92	47
80-99	41	19	51	26
50-79	20	9	34	17
25-49	3	1	6	3
1-24	5	2	9	5
0	5	2	3	2
TOTAL	**215**	**100**	**195**	**100**

Table 3. Road Segment Spacing by Road Gradient (in feet).

Road	Entire Data Base					
Grade	**AVG**	**RANGE**	**MEDIAN**	**SUM**	**No. of Segments**	**Rel. Freq.**
0 to 4	295	10-2240	175	207989	702	37
5 to 8	435	20-2310	345	96197	222	17
9 to 12	510	30-1950	415	119190	233	21
13 to 18	480	45-2110	360	107316	223	19
>18	335	55-1830	260	32658	98	6

Total =	380	10-2310	270	563350	1478	100

A total of 459 of these segments delivered directly to channels. The average length of the segments with delivery to channels was 436 feet. Twenty-five percent of the road system was observed to have direct sediment delivery potential (ditches either to streams or to gullies connected to streams, while another fourteen percent was given a possible sediment delivery rating. Distribution of discharge lengths above stream crossings (to the next cross drainage) is shown in Figure 3. Those discharges under 300 feet generally indicate a spacing to accommodate filtering, while those over 300 feet indicate significant potential flow and sediment accumulation. Forty-five percent of the discharge points had drainage lengths conducive to filtering.

Figure 4. Length of roads segments delivering directly to a steams (expressed as relative frequency to the number of these discharges).

Sources of Surface Erosion

The conditions of ditches were examined to detect either excess flow in ditch or insufficient size of ditch to carry flow. Thirty-nine percent of the surveyed road lengths had no ditch, although only three percent of the roads were outsloped. Most crowned roads (85 percent of the Kilchis system) are normally designed with ditches. For a significant portion of the Kilchis system, water flows on the inside edge of the road and not in a ditch. Most of the ditches (32 percent of the entire system) were functioning without excess blockage or erosion. Thirteen percent of the segments had excess sediment in ditches, and another eight percent had ditches partially impeded by vegetative growth. Six percent of the ditches had evidence of excess flows and ditch downcutting (prior to the winter of 1995-96).

Most of the road cutslopes (87 percent) were covered with vegetation. Average cutslope height was eight feet. Forty-four percent of culvert outlets showed no signs of significant erosion, while twenty-seven percent had significant erosion scour-holes below the outlet, and another twenty-three percent had channels or gullies developed below the outlet.

Ninety-five percent of the roads were classified as inactive (no log hauling). Forty-six percent of road surfaces were smooth (minimal erosion and well drained) while five percent were rutted. Thirty-three percent had irregular surface shapes. Ninety-six percent of road surfacing material was classified as "dirty rock" (gravel with an abundance of fines), while four percent of the roads were dirt surfaced.

Landslides and Washouts

A total of 57 landslides were identified. Forty-eight of the road or landing associated landslides that occurred during the winter of 1995-96 in the Kilchis watershed involved more than ten cubic yards of material. Another nine landslides that were less than ten cubic yards were also investigated during this study. There were twenty-two washouts which eroded greater than ten cubic yards of material, and there were another twenty-eight washouts of less than ten cubic yards volume.

Forty-five (94 percent) of the large landslides were failures of fill materials. Only three of the large landslides were cutslope failures. Most of the landslides (19) occurred where hillslopes were between 70 and 80 percent (Figure 4). Seven of the large landslides occurred at cross-drainage locations, and another ten of these landslides occurred where water diverted down the road flowed onto fill or sidecast slopes. Thirty-one of the large landslides (65 percent) were not associated with road drainage waters. At eleven of the landslide sites, significant volumes of wood was observed in the fills. Most of the large landslides (37) occurred on relatively straight sections of road (77 percent).

Figure 5. Road-related landslide occurrence by slope steepness.

Twenty-nine (60 percent) of the large landslides definitely entered channels, while another ten (21%) may have entered channels. Nine of the large landslides (19%) did not enter a channel. Total volume of landslides which entered or may have entered channels was 5,400 cubic yards (excluding debris flows). The largest landslide observed was 710 cubic yards.

Twelve of the large washouts occurred at stream crossings, while the other ten were associated with water diverted down the roads. Three of the large washouts were associated with fills fifteen feet or over in depth. Total sediment delivery to streams associated with large washouts was about 3,700 cubic yards. It is of significance to note that a single diversion/washout on Sam Downs Road eroded 2,425 cubic yards (66% of total washout volume).

Discussion

Culvert Spacing

The concurrent random road survey (ODF, 1996), and a study by Piehl and others (1988) evaluated culvert conditions and lengths of drainage segments. Piehl and others (1988) compared culvert spacings measured in the central Oregon coast range to those recommended by Arnold (1957). Measured spacings were compared against those Arnold (1957) recommended for silt-loam soils and a rainfall intensity of 1-2 inches per hour (Table 4).

Table 4. Arnold's Recommended Spacings for Silt Loam Soil.

Slope Class	Excess Length (Over Arnold's) Criteria
0-4	1500'
5-8	865'
9-12	480'
13-18	335'
over 18	250'

The average spacing of drainage discharges in the Kilchis watershed was 380 feet. For the random data base as a whole, it was 369 feet, and for the Coast Range georegion, it was 384 feet (ODF, 1996). The Piehl study (1988) found average cross-drain culvert spacing on state lands was 1.36 times and on private lands was 1.69 times that recommended by Arnold (1957). In the Kilchis watershed, 42% of the cross-drainage spacings exceeded that recommended by Arnold (1957). Most of these "over Arnolds" segments had road grades of over 9 percent, with the majority in the 13 to 18 percent classification.

Delivery to Streams

The percentage of the road system delivering sediment to streams (between 25 and 39 percent) was lower than the 57.3 percent reported by Wemple (1994) or the 75 percent reported by Reid and Dunne (1984). It was comparable with the 34 percent reported by Bilby and others (1989). It was exactly the same as the western Oregon random survey.

Average segment lengths from stream crossings to the first cross drainages above the stream crossings was 436 feet, while average spacing on the overall roads in general was 381 feet. This suggests that roads are designed and maintained for efficient delivery of water to channels, rather than for filtering. OAR 629-625-330(3) states "*Operators shall locate dips, water bars, or cross-drainage culverts above and away from stream crossings so that road drainage waters may be filtered before entering waters of the state*." Although this rule was recently modified for clarity and specificity, it has been in place since 1978.

However, many, probably most, of the roads surveyed were constructed prior to 1978. The average segment length delivering to streams in the random survey of western Oregon was 458 feet. Though the Kilchis distance was slightly smaller, this finding suggests that roads in western Oregon in general, including the Kilchis watershed, are not in the condition suggested by this rule.

The conditions of stream crossing culverts in the Kilchis watershed was compared to those of the random survey. Sixty-seven percent of the stream crossing pipes in the Kilchis watershed were completely open, as compared to 57 percent in the overall random survey, and 47 percent in the Coast Range georegion portion of the random survey. Forty-seven percent of the cross-drainage culverts were completely open in this survey, as compared to 50 percent in the entire random data set, and 45 percent in the Coast Range portion of the random data set. Piehl (1988) found that average stream crossing culvert area was 88 percent of original. The culverts in the Kilchis watershed have average inlet openings of 90% original (reduced by 10%). Therefore, maintenance of stream crossing culverts in the Kilchis watershed slightly exceeds that of western Oregon in general, while maintenance of cross-drainage culverts is similar to western Oregon in general.

Landslides and Washouts

Landslides and washouts are clearly the dominant erosional process associated with forest roads in the Kilchis watershed, especially in years when there are major storms. Analysis of the road-related landslides data will be conducted with the historical landslides analysis of the Kilchis watershed, and will be compared with the Wilson River Storm of 1996 monitoring study site, as well. Preliminary results indicate that landslide impacts in the Kilchis watershed are not as great as those experienced on the north fork of the Wilson River. Washout volume was about 60 percent of landslide volume, due mainly to a single diversion of a relatively small stream down a roadway, resulting in a gully up to 15 feet deep and 1200 feet in length.

Road Inventory Protocol

One of the original objectives of this project and the western Oregon random study was to develop a road sediment inventory protocol for use by state and private landowners. Additional emphasis was placed on this project by the Governor's Coastal Salmon Restoration Initiative (CSRI). The Oregon Forest Industries Council has volunteered to implement a "Road Hazard and Risk Reduction Project." To implement this project, a road inventory that assesses surface erosion, washouts, landslides, and fish passage hazards was required. The surface erosion and washout parts of the inventory have been taken from the road drainage inventory used in this study. The landslides and fish passage parts of the inventory were based on other ODF projects.

The final protocol is attached as Appendix 3. This protocol was designed for forest land managers use and to provide information needed in order to prioritize road management decisions, especially maintenance and repair activities. It is intended for priority use in areas where roads pose higher risks to anadromous fish and their habitats.

Relative Sources of Road Sediment

One objective of this study is to provide information for the Kilchis watershed analysis. In particular, two questions raised during the Kilchis watershed analysis working group meeting can be answered, at least in part, by this study. The questions are:

1) What is the relative proportion of sediment delivered to streams from shallow landslides, deep landslides, surface erosion on roads, culverts, surface erosion in the uplands, surface erosion in the lowlands?

2) Do we have enough information to produce a quantified volume estimate of the sediment delivered from shallow landslides, deep landslides, road surfaces, culverts, and surface erosion sources?

At the present time, it is possible to put the Kilchis forest roads into a relative sediment delivery perspective. It is also possible to estimate road-related sediment delivery. When the ODF study of landslides in the Kilchis watershed is complete, additional information on background, fire related, and upland management related sediment loadings should be available.

There are several hillslope processes that move sediment from hillslopes to channels. These processes are usually categorized as surface erosion, mass erosion, solute transport and channel bank erosion. As previously stated, surface erosion from forest lands of the Pacific Northwest is usually related to soil compaction or forest fires, which can both cause overland flow. Burning also causes dry ravel, where coarse sediment travels down steep slopes under the influence of gravity. After intense fires, intense precipitation often results in gully formation and channel extension.

Mass erosion includes landslides and creep. Creep is distinguished from landslides by the very slow movement (millimeters per year) and the lack of a failure surface (which for landslides clearly separates the landslide from "stable" land on the margins of the landslide.

Landslides are extremely variable in size, velocity, and mechanics of movement. Landslides are sometimes classified as "shallow-rapid" and deep-seated. "Shallow-rapid" slides are typical on steep forest hillslopes. These landslides often begin as small translational failures (where a block of soil fails at the soil-rock interface). When these small landslides continue moving downslope, they become debris flows. Debris flows typically scour most soil and organic matter along their paths. Upon entering and continuing down channels debris flows are considered debris torrents (Van Dine, 1985). Debris flows and torrents transport a great deal more sediment than the initiating landslide (usually between about 5 and 100 times the volume of the initiating landslide.

Deep-seated landslides are commonly slow moving and highly variable in size. However, in 1991, a rapidly moving deep-seated slide occurred along the Wilson River. This landslide moved approximately 500,000 cubic yards of mostly rock and some soil, and resulted in a partial landslide dam on the river.

High streamflows cause erosion of streambanks and alluvial terraces. Erosion by streamflow is accelerated by creep and earthflow movement of hillslopes around the channel. High streamflows also can also erode and sometimes washout roadway fill material, especially at stream crossings.

Hillslope erosional processes fall in a temporal continuum, from uniform to rare episodic, as shown below:

Continuous ================================> Very infrequent episodic

Creep ==> road surface erosion ==> channel erosion ==> slow landslides ==> rapid landslides

Large rainstorms, major wildfires, and earthquakes are likely to dominate sediment production in the Kilchis watershed. Therefore, the following estimates of sediment delivery consider both chronic and episodic processes.

Basis of Estimations

Of all studies of surface erosion from roads, the Black study was considered to have the most relevance to the Kilchis watershed (Black, T, 1997, Personal Communication). The Black study measured surface erosion sediment production for roads in the central coast range of Oregon from November 1995 to February 1996. The Black study sites are located in areas of sedimentary and volcanic rocks, and soils with similar properties to those in the Kilchis watershed. Average erosion for vegetated roadways was found to be 1 kilogram per meter (kg/m) of road length per year for roads of similar width to Kilchis forest roads. A 1 to 10 kg/m erosion rate was applied to the Kilchis road system, using the finding that up to forty percent of the Kilchis road system delivers its sediment load to channels (the other 60% is filtered by the forest floor).

The sediment production estimation for washouts is based on direct measurements made on Kilchis watershed roads. These estimates reflect a "major" storm, but not an "extreme" storm. The sediment production estimates for landslides are based on the landslide scar measurements made during the resurvey of the Kilchis watershed roads and on data from the ODF "Tillamook" study site. The road resurvey collected information on landslides, but not associated debris flows. Again, the resurvey data is representative of a "major," but not extreme storm. Estimates of debris flow volume (most of the sediment production) and "extreme" storm sediment production were developed using the "Tillamook" study site information.

Table 5. Estimates for Sediment Budget of the Kilchis Watershed

Source Type	Normal Year	Major Storm	Extreme Storm
Road Surface Erosion	50 - 500 yd^3	50 - 1,000 yd^3	100 - 5,000 yd^3
Road Washouts	100 yd^3	2,500 yd^3	25,000 yd^3
Road Landslides	2,000 yd^3	20,000 yd^3	200,000 yd^3
Abandoned Road Slides	0	5,000 yd^3	100,000 yd^3
Background Landslides	100 - 1,000 yd^3	1,000 - 100,000 yd^3	100,000 - 500,000 yd^3

Estimates are for the entire 47,000 acre watershed. Estimates do not include creep, bank erosion, or the effects of fire or earthquake. Effects of fire will be included in the landslides analysis study. An increase in road traffic could potentially increase surface erosion by a factor of 2 or more.

Conclusions

The condition of the road drainage system of the Kilchis watershed better minimizes delivery of sediment from surface erosion than the average of other forest roads in western Oregon. However, landslides and washouts are the dominant erosional processes in this watershed, and represent the most pressing concerns for road system management. Surface erosion of the road surfaces will become a much greater concern if winter log truck traffic increases significantly. Just prior to that time, road resurfacing and adding extra culverts for filtering above stream crossings would be appropriate. Additional analysis of the landslides situation will be completed with the Kilchis landslide study currently underway.

At the present time, the two principal surface erosion concerns in the Kilchis basin are:

1. Excessive length of ditch routed to deliver sediment directly to channels; and

2. Steep gradient roads (generally over 13 percent) with excessively spaced cross-drainage structures.

Although road surfaces are in many cases very uneven, the amount of rock and the lack of truck traffic poses only a low risk of erosion, as are presently used and maintained. Most cutslopes and fillslopes are very well vegetated (87 percent cover, on average) so generally pose low surface erosion hazards. However, there are specific isolated locations where road ravel is a serious problem. Slopes prone to ravel are quite difficult to stabilize, and normally must be dealt with by increased maintenance activity.

This study was originally designed to investigate surface erosion. It is now clear that landslides are the dominant source of road related erosion in the watershed. Landslides and washouts result in 90 to 99 percent of the sediment that enters Kilchis watershed streams. However, localized surface erosion, especially that associated with heavy traffic, may be significant. Erosion of fine surface materials can increase turbidity and the deposition of fine sediments in streambed gravels.

And, as a final note, although this study did not address fish passage through culverts, the road inventory protocol now addresses this important issue.

Road Management Recommendations (in order of priority)

1. Replace failing cedar puncheon culverts with steel culverts or bridges. Modify road grades to lower fills during this process to the extent road function is maintained.

2. Begin a program to pull back fills on excess width roads (over 19 feet and excluding turnouts) where sideslopes exceeds 70 percent and downslope risk of stream entry is high. Set a yearly goal for feet of pullback on high hazard locations.

3. Where possible, regrade stream crossings on midslope roads to allow streamflows to flow over the roads at the edges of the fills, rather than to flow down the roads (create a slight dip just before the crossing). Fill ditches at these location.

4. Utilize the road inventory protocol to survey other roads in the Tillamook bayshed to collect information on landslide hazard, fish passage, washout hazard, and surface erosion hazard

5. Remove existing berms on the outside edges of sidecast constructed roads.

6. Use the road database to find steep gradient roads (over 13%) with lengths over 1000 feet, and provide additional cross-drainage.

7. Prior to significant winter log truck traffic, resurface roads with crushed high quality aggregate (few fines) and add additional cross-drainage culverts for filtering within 100 to 200 feet of stream crossings.

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APPENDIX 1

OREGON'S FOREST ROAD CONSTRUCTION AND MAINTENANCE RULES

DIVISION 625
FOREST ROADS

Road Construction and Maintenance

Purpose

629-625-000 (1) Forest roads are essential to forest management and contribute to providing jobs, products, tax base and other social and economic benefits.

(2) OAR 629-625-000 through 629-625-650 shall be known as the road construction and maintenance rules.

(3) The purpose of the road construction and maintenance rules is to establish standards for locating, designing, constructing and maintaining efficient and beneficial forest roads; locating and operating rock pits and quarries; and vacating roads, rock pits, and quarries that are no longer needed; in manners that provide the maximum practical protection to maintain forest productivity, water quality, and fish and wildlife habitat.

(4) The road construction and maintenance rules shall apply to all forest practices regions unless otherwise indicated.

Prior Approval

629-625-100 (1) A properly located, designed, and constructed road greatly reduces potential impacts to water quality, forest productivity, fish, and wildlife habitat. To prevent improperly located, designed, or constructed roads, prior approval of the State Forester is required in the sections listed below.

(2) In addition to the requirements of the water protection rules, operators shall obtain prior approval from the State Forester before:

(a) Constructing a road where there is an apparent risk of road-generated materials entering waters of the state from direct placement, rolling, falling, blasting, landslide or debris flow.

(b) Conducting machine activity in Type F or Type D streams, lakes or significant wetlands.

(c) Constructing roads in riparian management areas.

(3) In the Northwest Oregon and Southwest Oregon Regions, operators shall obtain prior approval from the State Forester before constructing roads on high risk sites.

(4) Operators shall obtain written prior approval from the State Forester of a written plan, as described in OAR 629-625-320(1)(b)(B), before constructing any stream crossing fill over 15 feet deep.

(5) In addition to the requirements of the water protection rules, operators shall obtain prior approval from the State Forester before placing woody debris or boulders in stream channels for stream enhancement.

Road Location

629-625-200 (1) The purpose of this rule is to ensure roads are located where potential impacts to waters of the state are minimized.

(2) When locating roads, operators shall designate road locations which minimize

the risk of materials entering waters of the state and minimize disturbance to channels, lakes, wetlands and floodplains.

(3) Operators shall avoid locating roads on steep slopes, slide areas, high risk sites, and in wetlands, riparian management areas, channels or floodplains where viable alternatives exist.

(4) Operators shall minimize the number of stream crossings.

(5) To reduce the duplication of road systems and associated ground disturbance, operators shall make use of existing roads where practical. Where roads traverse land in another ownership and will adequately serve the operation, investigate options for using those roads before constructing new roads.

Road Design

629-625-300 (1) The purpose of OARs 629-625-300 through 629-625-340 is to provide design specifications for forest roads that protect water quality.

(2) Operators shall design and construct roads to limit the alteration of natural slopes and drainage patterns to that which will safely accommodate the anticipated use of the road and will also protect waters of the state.

Road Prism

629-625-310(1) Operators shall use variable grades and alignments to avoid less suitable terrain so that the road prism is the least disturbing to protected resources, avoids steep sidehill areas, wet areas and potentially unstable areas as safe, effective vehicle use requirements allow.

(2) Operators shall end-haul excess material from steep slopes or high risk sites where needed to prevent landslides.

(3) Operators shall design roads no wider than necessary to accommodate the anticipated use.

(4) Operators shall design cut and fill slopes to minimize the risk of landslides.

(5) Operators shall stabilize road fills as needed to prevent fill failure and subsequent damage to waters of the state using compaction, buttressing, subsurface drainage, rock facing or other effective means.

Stream Crossing Structures

629-625-320 (1) Operators shall design and construct stream crossing structures (culverts, bridges and fords) to:

(a) Minimize excavation of side slopes near the channel.

(b) Minimize the volume of material in the fill.

(A) Minimizing fill material is accomplished by restricting the width and height of the fill to the amount needed for safe use of the road by vehicles, and by providing adequate cover over the culvert or other drainage structure.

(B) Fills over 15 feet deep contain a large volume of material that can be a considerable risk to downstream beneficial uses if the material moves downstream by water. Consequently, for any fill over 15 feet deep operators shall obtain approval of the State Forester of a written plan that describes the fill and drainage structure design.

Approval of such written plans shall require that the design be adequate for minimizing the likelihood of surface erosion, embankment failure, and other downstream movement of fill material.

(c) Prevent erosion of the fill and channel.

(2) Operators shall design and construct stream crossings (culverts, bridges, and fords) to:

(a) Pass a peak flow that at least corresponds to the 50-year return interval. When determining the size of culvert needed to pass a peak flow corresponding to the 50-year return interval, operators shall select a size that is adequate to preclude ponding of water higher than the top of the culvert; and

(b) Allow migration of adult and juvenile fish upstream and downstream during conditions when fish movement in that stream normally occurs.

(3) An exception to the requirements in subsection (2)(a) of this rule is allowed to reduce the height of fills where roads cross wide flood plains. Such an exception shall be allowed if:

(a) The stream crossing site includes a wide flood plain ; and

(b) The stream crossing structure matches the size of the active channel and is covered by the minimum fill necessary to protect the structure;

(c) Except for culvert cover, soil fill is not placed in the flood plain: and

(d) The downstream edge of all fill is armored with rock of sufficient size and depth to protect the fill from eroding when a flood flow occurs.

Drainage

629-625-330 (1) Operators shall provide a drainage system using grade reversals, surface sloping, ditches, culverts and/or waterbars as necessary to effectively control and disperse surface water to minimize erosion of the road.

(2) Operators shall not divert water from channels except as necessary to construct stream crossings.

(3) Operators shall locate dips, water bars, or cross-drainage culverts above and away from stream crossings so that road drainage water may be filtered before entering waters of the state.

(4) Operators shall provide drainage when roads cross or expose springs, seeps, or wet areas.

(5) Operators shall not concentrate road drainage water into headwalls, slide areas, or high risk sites.

Waste Disposal Areas

629-625-340 Operators shall select stable areas for the disposal of end-haul materials, and shall prevent overloading areas which may become unstable from additional material loading.

Road Construction

629-625-400 OARs 629-625-400 through 629-625-440 provide standards for disposal of waste materials, drainage, stream protection, and stabilization to protect water quality during and after road construction.

Disposal of Waste Materials

629-625-410 Operators shall not place debris, sidecast, waste, and other excess materials associated with road construction in locations where these materials may enter waters of the state during or after construction.

Drainage

629-625-420 (1) Operators shall clear channels and ditches of slash and other road construction debris which interferes with effective roadway drainage.

(2) Operators shall provide effective cross drainage on all roads, including temporary roads.

(3) Operators shall install drainage structures on flowing streams as soon as feasible.

(4) Operators shall effectively drain uncompleted roads which are subject to erosion.

(5) Operators shall remove berms on the edges of roads or provide effective drainage through these berms, except for those berms intentionally designed to protect road fills.

Stream Protection

629-625-430 (1) When constructing stream crossings, operators shall minimize disturbance to banks, existing channels, and riparian management areas.

(2) In addition to the requirements of the water protection rules, operators shall keep machine activity in beds of streams to an absolute minimum. Acceptable activities where machines are allowed in streambeds, such as installing culverts, shall be restricted to periods of low water levels. Prior approval of the State Forester for machine activity in Type F or Type D streams, lakes, and significant wetlands is required by 629-625-100(2)(c).

(3) For all roads constructed or reconstructed operators shall install water crossing structures where needed to maintain the flow of water and passage of adult and juvenile fish between side channels or wetlands and main channels.

(4) Operators shall leave or re-establish areas of vegetation between roads and waters of the state to protect water quality.

(5) Operators shall remove temporary stream crossing structures promptly after use, and shall construct effective sediment barriers at approaches to channels.

Stabilization

629-625-440 (1) Operators shall stabilize exposed material which is potentially unstable or erodible by use of seeding, mulching, riprapping, leaving light slashing, pull-back, or other effective means.

(2) During wet periods operators shall construct roads in a manner which prevents sediment from entering waters of the state.

(3) Operators shall not incorporate slash, logs, or other large quantities of organic material into road fills.

Rock Pits and Quarries

629-625-500 (1) The development, use and abandonment of rock pits or quarries which are located on forestland and used for forest management shall be conducted using practices which maintain stable slopes and protect water quality.

(2) Operators shall not locate quarry sites in channels.

(3) When using rock pits or quarries, operators shall prevent overburden, solid wastes, or petroleum products from entering waters of the state.

(4) Operators shall stabilize banks, headwalls, and other surfaces of quarries and rock pits to prevent surface erosion or landslides.

(5) When a quarry or rock pit is inactive or vacated, operators shall leave it in the conditions described in section (4) of this rule, shall remove from the forest all petroleum-related waste material associated with the operation; and shall dispose of all other debris so that such materials do not enter waters of the state.

Road Maintenance

629-625-600 (1) The purpose of this rule is to protect water quality by timely maintenance of all active and inactive roads.

(2) Operators shall maintain active and inactive roads in a manner sufficient both to provide a stable surface and to keep the drainage system operating as necessary to protect water quality.

(3) Operators shall inspect and maintain culvert inlets and outlets, drainage structures and ditches before and during the rainy season as necessary to diminish the likelihood of clogging and the possibility of washouts.

(4) Operators shall provide effective road surface drainage, such as water barring, surface crowning, constructing sediment barriers, or outsloping, prior to the rainy and runoff seasons.

(5) When applying road oil or other surface stabilizing materials, operators shall plan and conduct the operation in a manner as to prevent entry of these materials into waters of the state.

(6) In the Northwest and Southwest Oregon Regions, operators shall maintain and repair active and inactive roads as needed to minimize damage to waters of the state. This may include maintenance and repair of all portions of the road prism during and after intense winter storms, as safety, weather, soil moisture and other considerations permit.

(7) Operators shall place material removed from ditches in a stable location.

(8) In order to maintain fish passage through water crossing structures, operators shall:

(a) Maintain conditions at the structures so that passage of adult and juvenile fish is not impaired during periods when fish movement normally occurs. This standard is required only for roads constructed or reconstructed after September 1994, but is encouraged for all other roads; and

(b) As reasonably practicable, keep structures cleared of woody debris and deposits of sediment that would impair fish passage.

(c) Other fish passage requirements under the authority of ORS 498.268 and

509.605 that are administered by other state agencies may be applicable to water crossing structures, including those constructed before September 1, 1994.

Vacating Forest Roads

629-625-650 (1) The purpose of this rule is to ensure that when landowners choose to vacate roads under their control, the roads are left in a condition where road related damage to waters of the state is unlikely.

(2) To vacate a forest road, landowners shall effectively block the road to prevent continued use by vehicular traffic; and shall take all reasonable actions to leave the road in a condition where road-related damage to waters of the state is unlikely.

(3) Reasonable actions to vacate a forest road may include: removal of stream crossing fills; pullback of fills on steep slopes, frequent cross ditching, and/or vegetative stabilization.

(4) Damage which may occur from a vacated road, consistent with Sections (2) and (3) of the rule, will not be subject to remedy under the provisions of the Oregon Forest Practices Act.

APPENDIX 2

Oregon Department of Forestry's Forest Practices Monitoring Program

The Forest Practices Monitoring Program (FPMP) is designed to assess the effectiveness, implementation and assumptions of the forest practice rules in achieving the goals of the Oregon Forest Practices Act (FPA). The goal of the FPMP is to provide timely information and analysis of the forest practice rules. Findings and recommendations are made to the Oregon Board of Forestry. The foundation of the program is a group of monitoring questions developed with input from interested public, private and public landmanagers, the research community and forest practices staff. The questions address monitoring and research issues in four key resource areas requiring protection under the FPA. Those categories are: (1) forest and soil productivity, (2) fish and wildlife, (3) water quality, and (4) air quality. The specific objectives of the FPMP are to:

- Evaluate the effectiveness of the FPA and rules to encourage economically efficient forest practices while protecting forest productivity, water quality, air quality and fish and wildlife at a variety of scales and over time.
- Assess the implementation of the act and rules.
- Assess the assumptions built into the Act and rules.
- Foster a general consensus on monitoring priorities and approach.
- Provide timely feedback on the effectiveness of the rules.
- Approach all issues efficiently.
- Facilitate coordination and cooperation on monitoring efforts.
- Approach all monitoring questions from a sound scientific foundation.
- Encourage research that will provide information on intensively managed forest systems and the effects of regulated forest practices.
- Synthesize and report other relevant information on the effects of forest practices.

In the context of the Forest Practices Act, adaptive management is a continuous process of rule refinement, implementation, monitoring, evaluation, and adjustment. The overall strategy of the monitoring program is to focus on integrating information and evaluation efforts through coordinated monitoring, research and the synthesis of other studies and information. The resulting body of information will be used in the adaptive management process. The following is a brief description of individual projects designed to answer questions from the FPMP Strategic plan that are being implemented (1-4) or planned for implementation (5-7).

1.) **Statewide Basin and Reach-level Stream Temperature Monitoring**

- *Are the stream protection rules effective in maintaining stream temperature within the context of the inherent basin trend?*
- *What stream, basin and vegetation characteristics influence the temperature regime and how do these vary across the state?*

These projects are designed to assess stream temperature at a reach and basin scale. Effects of units harvested using the 1994 protection rules and environmental controls on stream temperature are being monitored.

2.) **Riparian Condition and Implementation**

- *What levels of large wood will be maintained in channels and through a watershed under the vegetation retention standards?*
- *Are the vegetation retention rules resulting in conditions that are consistent with the goal of achieving mature forest conditions within the next rotation?*

This project is designed to assess the effect of forest practices on riparian function and structure. Riparian shade and composition, large woody debris recruitment and wildlife habitat components are being monitored in riparian areas left under the 1994 stream protection rules.

3.) **1996 Storm Impacts Monitoring Project**

- *Were the forest practices in the sample areas appropriate for the time of the operation and did they minimize or contribute to impacts?*
- *How are hillslope processes and forest practices linked to channel responses or impacts?*

This project was initialized in response to the February 1996 storm which affected mostly northwestern Oregon. Landslide frequency and size, channel impacts and fish habitat are beginning assessed under varying management and road conditions.

4.) **Road Sediment Monitoring and Protocol Development and Kilchis Watershed Analysis**

- *Are best management practices minimizing the delivery of sediment to waters of the* *state?*

These projects are designed to inventory roads throughout the state. A protocol was designed for use by landowners to assess the condition of roads and potential delivery of sediment to stream channels from the roadway. In addition sediment contributions from roads and landslides was monitored throughout an entire watershed.

5.) **Determining Fish Passage through Culverts**

- *Are water crossing structures passing fish as anticipated?*

Information from this project will be used to define easy-to-measure parameters that landowners and operators can use to install culverts properly and determine if existing culverts pass fish.

6.) **Protection of Waters of the State during Pesticide Application**

- *Is water quality including the integrity of aquatic communities and public health, being effectively protected when forest management chemicals are applied?*

This project is designed to test the effectiveness of chemical rules adopted in 1996 as well as the effect of increasing the miles of stream that receive greater protection due to the 1994 reclassification of streams.

7) **Statewide Implementation of the Forest Practice Rules**

- *What percentage of forest practice operations result in proper implementation of the Forest Practice rules?*

This project is in the protocol development stage and will be a statewide sample of forest operations.

APPENDIX 3

Road Erosion Hazard Inventory Protocol