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EFFECTIVENESS OF FOREST ROAD AND TIMBER HARVEST BEST MANAGEMENT PRACTICES WITH RESPECT TO SEDIMENT-RELATED WATER QUALITY IMPACTS

Interim Report No. 2

May 1994
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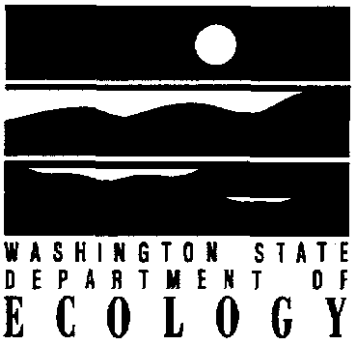

EFFECTIVENESS OF FOREST ROAD AND TIMBER HARVEST BEST MANAGEMENT PRACTICES WITH RESPECT TO SEDIMENT-RELATED WATER QUALITY IMPACTS

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ABSTRACT

This study to evaluate the effectiveness of certain forest road and timber harvest best management practices (BMPs) is being conducted as a part of the Timber/Fish/Wildlife Cooperative Monitoring, Evaluation, and Research Program. The purpose of this second Interim Report is to provide an overview of the study design, summarize study site information, and report on progress to date. The project is employing a case study approach to evaluating BMP effectiveness. A total of 90 examples of typical BMPs, implemented under varying degrees of landscape hazard, have been selected from six of the nine physiographic regions of Washington. General BMP categories targeted in the study include road construction practices, road maintenance practices, and timber harvesting practices. A number of qualitative and quantitative survey techniques are being employed to assess erosion and sediment delivery to streams, characterize stream channel, runoff, and aquatic habitat conditions, and assess biological communities. In most cases, two or more survey techniques am applied to each BMP example studied. The different survey techniques will provide different kinds of evidence on forest practice effects, leading to a weight-of-evidence approach to determining BMP effectiveness. Thirty-six study sites have been identified for the project, at which 90 specific BMP examples are being evaluated. These include 47 harvesting BMPs (tractor/wheeled skidding, Riparian Management Zones, and Riparian Leave Tree Areas), 39 new road construction BMPs (road drainage design, culvert installation, and construction techniques), and 4 road maintenance BMPs (active haul road maintenance).

INTRODUCTION

This study to evaluate the effectiveness of certain forest road and timber harvest best management practices (BMPs) is being conducted by the Department of Ecology as a part of the Timber/Fish/Wildlife Cooperative Monitoring, Evaluation, and Research Program (CMER). The project is sponsored by CMER's Water Quality Steering Committee, which provides project review and technical oversight.

The purpose of this second Interim Report is to briefly describe the study approach, summarize the status of evaluations at the study sites, note changes in the study since the last interim report, and provide brief narrative descriptions of each study site. Interim Report No. 1 more fully describes the sampling design and evaluation methods for the study, and contains descriptions of detailed field survey protocols (Rashin et al., 1993). The final project report is scheduled to be completed in January 1996.

The Washington Forest Practices Rules and Regulations (Title 222 WAC) contain numerous BMPs intended to minimize the impacts of erosion and sedimentation on water quality. The overall test of BMP effectiveness will be the extent to which the BMPs achieve compliance with Washington's surface water quality standards by avoiding sediment-related water quality impacts from forest management activities. These standards prohibit the degradation of aquatic resources in such a manner that it impairs the suitability of water for any aquatic life, wildlife, or human use (i.e., beneficial uses). The standards apply to all types of surface waters.

The water quality standards regulation (Chapter 173-201A WAC) includes both numeric and narrative (Le., descriptive) criteria that apply to sediment-related impacts. Numeric criteria for turbidity prohibit an increase of 5 NTU, or 10% over background levels, whichever is greater. Narrative criteria that apply to sediment include a general requirement that the level of water quality must meet (or in the case of Class AA waters, exceed) the requirements of characteristic water uses (i.e., beneficial uses). Other narrative criteria prohibit materials which may adversely affect characteristic uses, cause acute or chronic adverse conditions to aquatic biota, or impair aesthetic values. Other than turbidity, however, there are a lack of clear, numeric criteria for determining when sediment-related impacts violate water quality standards. For the purpose of determining BMP effectiveness, various decision criteria for applying narrative water quality standards to forest practice impacts must be developed.

The objectives of the project are to:

1) gather qualitative and quantitative information on BMP effectiveness by monitoring representative examples of selected timber harvesting, road construction, and road maintenance practices;
2) develop and apply decision criteria for determining whether water quality standards are met where forest practice-related sediment impacts are concerned;
3) evaluate and describe the factors influencing BMP effectiveness; and

4) determine whether certain BMPs require modifications in order to achieve water quality standards, and to recommend such changes.

OVERVIEW OF STUDY DESIGN

We are using a case study approach to evaluate the effectiveness of the BMPs targeted for investigation. Our goal is to evaluate typical BMPs implemented under varying degrees of inherent landscape hazard in different physiographic regions of the state. We are using a weight-of-evidence approach that considers results from multiple survey techniques to determine the effectiveness of BMPs implemented in a variety of settings.

The sample of forest practices is grouped according to general BMP categories, which are stratified according to physiographic regions and relative hazard classes. The BMPs evaluated in this project are presented in Appendix A, which contains excerpts from the Forest Practice Rules (Title 222 WAC). These BMPs include new road construction techniques, road drainage design, stream crossings and culvert installation, maintenance of active ("mainline") haul roads, tractor and wheeled skidding, riparian management zones (including stream bank integrity practices), and riparian leave tree areas. The BMPs identified as "tractor and wheeled skidding" include various ground-based yarding systems including rubber-tired and tracked skidders as well as shovel logging, which is becoming increasingly common as a ground-based method. In most cases, we are assessing more than one specific BMP example at a given forest practice unit or study site.

While we are not specifically targeting evaluation of BMPs identified as "lower priority" in the project study plan (Rashin, 1992), we may obtain some information on their effectiveness where this is reflected in our surveys of other practices. For example, in some cases we will evaluate the effectiveness of Riparian Management Zones (RMZs) or Riparian Leave Tree Areas (RLTAs) within units where cable-yarding is used. In evaluating the effectiveness of the stream buffers, we will gather secondary information on the effects of cable-yarding practices. Also, since ground-based yarding systems are often used in conjunction with cable-yarding techniques at the same harvest operation, we may develop information on the effectiveness of cable-yarding with surveys that are generally targeted at evaluating the effects of yarding in the vicinity of streams.

Study sites are located in six of the nine physiographic regions of the state. The distribution of BMP examples among the physiographic regions is based on the approximate proportions of FPAs submitted for these regions. We used the Forest Practice Program 1991 Calendar Year Report (Department of Natural Resources, 1992) as a guide to this distribution.

For purposes of stratifying the sample according to degree of landscape hazard, we identify high, moderate, and low hazard categories based on the slope gradient of valley wall side slopes adjacent to the stream reaches where we are conducting our surveys. The slope hazard category for each BMP example is based on the steepest hillslope gradient in the

vicinity of streams within harvest areas, or at stream crossings for road BMPs. We use slightly different schemes for harvesting and road-related BMPs. The hazard classification scheme is presented below in Table 1.

TABLE 1: SLOPE HAZARD CLASSIFICATION
(For Purposes of Sample Stratification)

BMP Category	LOW	MODERATE	HIGH
Harvesting BMPs	0-19% slope	2040% slope	>40% slope
New Road Construction & Road Maintenance BMPs	0-19% slope	20-50% slope	>50% slope

Field Survey Methods

In order to systematically gather qualitative and quantitative information on BMP effectiveness, we developed and field-tested numerous survey methodologies during the pilot phase of the study. Our field survey protocols are presented in the first interim report (Rashin *et* al., 1993). The reader is referred to these protocols for field methods, working assumptions, and factors to be considered in determining BMP effectiveness. Study site selection criteria are also described in Interim Report No. 1. All of the surveys used in this study are designed to evaluate localized effects on streams which occur within the first two to three years following site-specific application of BMPs. Because of the need to minimize the confounding influences of multiple land management practices (i.e., cumulative effects), stream reaches being studied must be located immediately adjacent to or downstream of the practices being evaluated. As a result of this criterion, most of the streams assessed by this project are relatively small, low order (Type 3, 4, and 5 Waters) streams representative of headwater aquatic environments. While we are avoiding contemporary cumulative effects to the greatest practical extent, our study sites (with a few exceptions) are located on second-growth forest lands, hence most sites exhibit some impacts from past logging practices. Such historical impacts are generally unavoidable on most of the state and private commercial forest lands where examples of current BMPs were available for study.

For evaluation of harvest BMPs, preliminary instream surveys are generally conducted on treatment and control reaches prior to practices occurring in the vicinity of study reaches. Follow-up surveys are then conducted after the completion of harvest operations for 1% to 3 years, depending on the timing of the harvest. In a few cases, preliminary instream surveys were conducted soon after or during harvest operations. Though less than ideal, this was deemed acceptable where our observations indicated that sediment transport from

hillslope areas to streams had not occurred, or that no major hydrologic events had occurred since areas near streams were harvested. Unlike instream surveys, sediment routing surveys and certain skid trail surveys arc designed to be conducted after harvesting is completed. Surveys such as these, which evaluate erosion, sediment delivery, and recovery of disturbed areas over time, arc conducted two or more times following the harvest over a 1½-3 year period.

For evaluation of new road construction practices, surveys are used which evaluate erosion of cutslopes, fills, and ditches, and subsequent delivery of sediment to streams. Such surveys are designed to be conducted following road construction, and are repeated two or more times over the course of the study (i.e., for 2-3 years following road construction). At some road construction sites, instream surveys are used in conjunction with road prism surveys to evaluate the effects of sediment delivery and road drainage on stream reaches immediately downstream from road crossings.

To assess active haul road maintenance practices, the condition of road surfaces are evaluated concurrently with runoff sampling. These surveys are designed to be conducted during runoff-producing precipitation events on roads experiencing log hauling traffic (at least four loaded trucks per day). Qualitative channel condition surveys are conducted on the reaches sampled upstream and downstream of the road to evaluate local influences, other than the road itself, that may contribute to the suspended sediment load and complicate the analysis, of runoff sampling results.

For instream surveys, a control reach is usually located on the same stream, upstream of the harvest boundary or the newly constructed road, or on a nearby stream. Criteria for assuring sufficient similarity of treatment and control reaches are described in Interim Report No. 1. For purposes of this study, control reaches do not necessarily represent streams, which have not been affected by past forest practices, as most are located on previously managed commercial forest lands. They are controls in the sense that they are not subject to site-specific effects from the practice under evaluation, hence they facilitate the evaluation of the net effect, or change from preexisting conditions, that may result from the practices under evaluation. At two of our study sites, the control reaches have been compromised by unanticipated forest practice activity, and in a few other cases we were unable to find suitable site-specific control reaches. These cases are noted in the study site descriptions contained in Appendix B. In such cases, results from instream surveys will still yield information on changes in the treatment reaches that may occur over the course of the study, but we will have to rely on other control reaches from the physiographic region for general comparison purposes.

Determination of BMP Effectiveness:

This project will use a weight-of-evidence approach to determine BMP effectiveness. We generally use a combination of survey techniques to gather evidence of effectiveness for each BMP example studied. The surveys allow us to collect different hinds of information on

various water quality-related parameters. Some surveys will provide evidence of erosion in upland areas and sediment delivery to streams, while others will provide evidence of changes in aquatic habitats (i.e., stream channels) or biological communities. In addition to collecting different kmds of evidence, the different survey techniques also vary in their sensitivity for detecting changes in stream channels, hillslope erosion, and sediment delivery and storage, with some surveys sensitive only to gross changes and others able to detect more subtle effects.

The weight-of-evidence approach is illustrated in Figure 1. The results of each survey will be evaluated using decision criteria which relate survey results to the water quality standards and erosion processes the BMP is intended to control. Survey results will fall into one of three categories: "Yes," the BMP example was effective; "No," the BMP example was not effective; or, in some cases, "Indeterminate," meaning effectiveness could not be determined for this BMP example with the survey technique used. Indeterminate calls may be used where it is found that the survey technique was not appropriate to document the type of change that occurred at a particular site, or where interferences did not allow adequate evaluation of a particular practice. The evidence from the different survey techniques employed will be used collectively to determine effectiveness of that particular BMP example. However, since the survey techniques vary in their sensitivity, all survey results may not be weighted equally. The overall BMP effectiveness call for each example will be either "Yes," "No," or "Partially Effective" (in the case of mixed results).

Tests of BMP effectiveness will be based on narrative and numeric water quality standards issues, especially evidence of beneficial use impairment. State water quality standards apply to all water types (e.g., Types 1-5), and depend to a large degree on the existing and potential beneficial uses of the streams. For example, Type 1-3 streams are protected for fish use (e.g., spawning, rearing, and migration), while for smaller streams, aquatic life uses might include amphibian and macroinvertebrate habitat. In addition, water quality protection for downstream waters is an important beneficial use of headwater streams. Effectiveness or ineffectiveness may be reflected in assessments of erosion and sediment delivery to streams, stream channel/aquatic habitat condition, direct assessment of biota, or a combination of these types of information. For instream surveys, determining the effects of the BMP example will be based largely on changes in the magnitude or rate of streambank erosion and destabilization, sediment deposition, or streambed destabilization in the treatment reach relative to the control reach.

The survey protocols presented in Interim Report No. 1 contain conceptual approaches for rating BMP effectiveness. Development of final decision criteria for determining whether water quality standards are achieved, including criteria for interpreting narrative water quality standards, will be a significant part of the analysis effort. The effort to develop. decision criteria will include literature review and consultation with the Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts. One or more interdisciplinary work groups will be established to help formulate decision criteria.

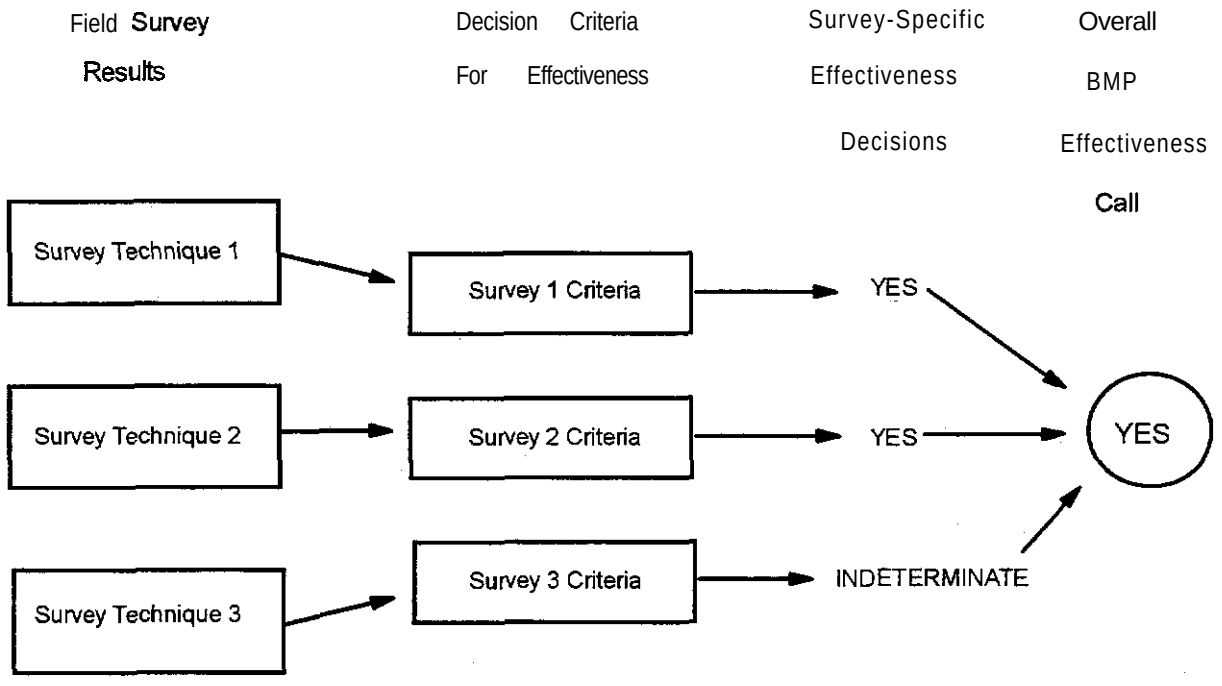

Figure 1: Weight-of-Evidence Approach for Determining BMP Effectiveness

(Applied to Each BMP Example)

We are assessing multiple examples of each BMP to make an overall determination of whether the practice is effective, partially effective, or not effective, and under what situations. Factors associated with BMP effectiveness or ineffectiveness will be described. Based on these factors, recommendations will be developed for enhancing the forest practice rules to prevent sediment-related water quality impacts. Other available information on forestry BMP effectiveness may also be considered in developing recommendations. This could include information obtained from literature reviews, as well as BMP effectiveness information gained from watershed analysis efforts in Washington State.

In developing the study design we identified several null hypotheses that we are testing, which were presented in Interim Report No. 1. These hypotheses address BMP effectiveness from the standpoint of what each BMP is designed to accomplish. We also identified several fundamental assumptions dealing with the erosion and sedimentation processes potentially affected by forest practices, tests of BMP effectiveness, and the sensitivity of various monitoring methods. Our key working assumptions are summarized below:

* Certain forest practices have the potential to accelerate erosion processes, and sediment from such accelerated erosion may be delivered to streams and other waterbodies where it may be deposited and/or transported downstream. While erosion and sedimentation may be accelerated by forest practices, they also occur as natural processes.

* The Best Management Practices evaluated by this study are intended to ensure that water quality standards are met by controlling erosion and sediment delivery to waterbodies, and protecting the integrity of streams with respect to erosion and sediment storage.

* Achievement of the water quality standards is the primary test of BMP effectiveness. Accelerated erosion with sediment delivery to streams, or stream channel destabilization, may violate state water quality standards when caused by forest practices and other human activities, particularly where existing or potential beneficial uses of surface waters are adversely affected. Aquatic life uses are particularly sensitive to erosion and sedimentation, and the water quality standards require protection of the most sensitive species and communities.

* Monitoring techniques differ in their sensitivity to detecting changes in erosion, sediment delivery to streams, sediment storage, and stream channel stability. Some techniques are only sensitive to gross changes in erosion and sedimentation rates, while others are more sensitive to subtle changes.

STUDY SITE SUMMARY

To date we have selected 36 study sites at which we are evaluating 90 examples of specific BMP implementation. Study site locations are shown on a map of physiographic regions in Figure 2. Table 2 summarizes study sites according to physiographic regions, BMPs evaluated, and the slope hazard categories described earlier. We have grouped BMP

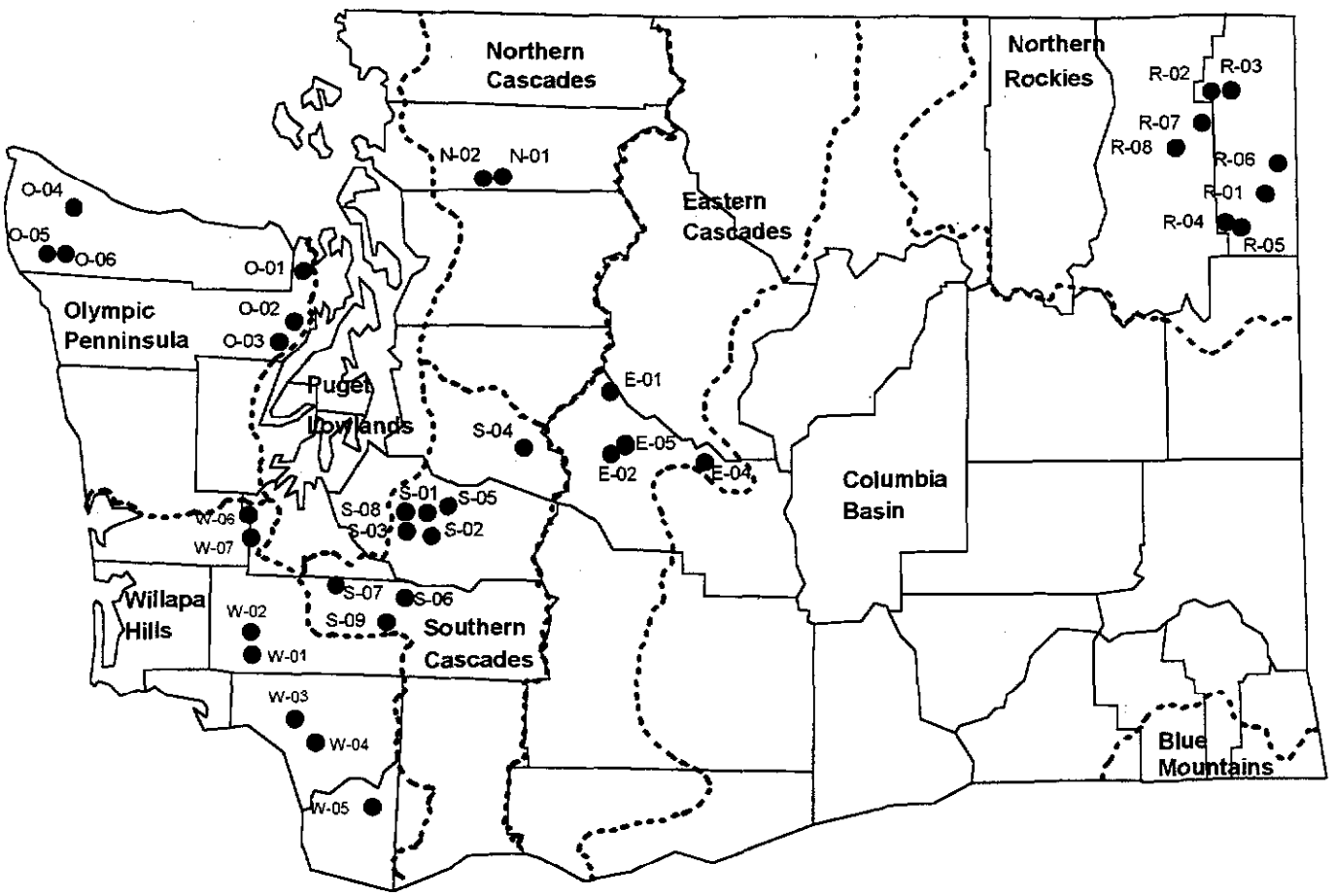

Figure 2: Physiographic Regions and Study Site Locations

Table 2: Study Site Summary

Physiographic Region	Site ID #	BMP Category Evaluated	Specific BMP Evaluated	Slope Hazard category
Olympic Peninsula	O-01	Harvest	Tractor/Wheeled Skidding RMZ	High
	O-02	Harvest	RLTA Tractor/Wheeled Skidding	Moderate
	O-03	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques	High
	0-04	Road Maintenance	Active Haul Road Maintenance	Moderate
	O-05	Harvest	Tractor/Wheeled Skidding RMZ	High
		New Road Construction	Culvert Installation Construction Techniques Road Drainage Design	High
	O-06	Harvest	Tractor/Wheeled Skidding RMZ	Moderate
Willapa Hills	W-01	Harvest	RMZ Tractor/Wheeled Skidding	Moderate
	W-02	Harvest	Tractor/Wheeled Skidding RMZ	Moderate
		New Road Construction	Culvert Installation Construction Techniques Road Drainage Design	Moderate
	W-03	New Road Construction	Culvert Installation Road Drainage Design Construction Techniques	High
	W-04	Road Maintenance	Active Haul Road Maintenance	Moderate
	W-05	New Road Construction	Culvert Installation Road Drainage Design Construction Techniques	Moderate
	W-06	Harvest	RMZ	High
	W-07	Harvest	RMZ	High
Southern Cascades	S-01	Road Maintenance	Active Haul Road Maintenance	Low
	S-02	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques	Moderate
	S-03	New Road Construction	Road Drainage Design Construction Techniques Culvert Installation	High
	S-04	Harvest	RMZ	High
	S-05	Harvest	RLTA	High
	S-06	Harvest	Tractor/Wheeled Skidding RLTA	High
	S-07	Harvest	RMZ Tractor/Wheeled Skidding	High
	S-08	Harvest	RMZ Tractor/Wheeled Skidding	High
	S-09	Harvest	RMZ Tractor/Wheeled Skidding	High

Table 2: Study Site Summary (cont.)

Physiographic Region	Site ID #	BMP Category Evaluated	Specific BMP Evaluated	Slope Hazard Category
Northern Cascades	N-01	Harvest	Tractor/Wheeled Skidding RLTA	Moderate
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation	Moderate
	N-02	Road Maintenance	Active. Haul Road Maintenance	Moderate
Eastern Cascades	E-01	New Road Construction	Culvert Installation (Temporary) Road Drainage Design Construction Techniques	High
		Harvest	Tractor/Wheeled Skidding	High
	E-02	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques	Moderate
	E-04	Harvest	Tractor/Wheeled Skidding RMZ	High
	E-05	Harvest	Tractor/Wheeled Skidding RMZ	Low
Northern Rockies	R-01	New Road Construction	Culvert Installation Road Drainage Design Construction Techniques	To be Determined
		Harvest	Tractor/Wheeled Skidding RMZ	To be Determined
	R-02	Harvest	RMZ Tractor/Wheeled Skidding	High
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation	Moderate
	R-03	Harvest	RMZ Tractor/Wheeled Skidding	Moderate
	R-04	Harvest	RMZ Tractor/Wheeled Skidding	Moderate
	R-05	Harvest	RMZ /Tractor/Wheeled Skidding	High
	R-06	Harvest	RMZ Tractor/Wheeled Skidding	High
	R-07	Harvest	RMZ Tractor/Wheeled Skidding	High
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation	High
	R-08	Harvest	RMZ Tractor/Wheeled Skidding	Low

examples into three general categories: harvesting, new road construction, and road maintenance. Within these general categories, we have identified "specific BMPs" which are groupings of closely related practices as listed in the Washington Forest Practices Rules and Regulations (Title 222 WAC--see Appendix A). Thus, each study site has one or more specific BMP example to be evaluated, and each specific BMP example may represent one or more individual practices, as listed in the WAC.

The 90 BMP examples selected to date include: 47 harvesting BMPs (tractor/wheeled skidding, Riparian Management Zones, and Riparian Leave Tree Areas); 39 new road construction BMPs (road drainage design, culvert installation, and construction techniques); and 4 road maintenance BMPs (active haul road maintenance). Table 3 is a matrix that shows the surveys used to evaluate the specific BMP examples for each site. In addition to the BMPs listed in Tables 2 and 3, surveys at some of the sites may provide secondary information on the effectiveness of cable-yarding practices where these are used in conjunction with RMZs, RLTAs, or ground-based yarding practices. This matrix was also presented in Interim Report No. 1, but the surveys identified differ for some of the study sites. As stated in the first interim report, planned surveys were subject to change in cases where they were dependent on weather or the timing of forest practices. In addition to these factors, we also found it necessary to make some changes due to the impact of budget cuts that affected the project. In order to adjust for these budget cuts, we allowed one of our project staff positions to remain vacant from August 1993 until January 1994, reducing our ability to complete planned preliminary surveys.

We were not able to conduct macroinvertebrate sampling on most of the sites where it was planned; such sampling was completed on only one harvest site and its control stream during 1993. Since most of the harvest operations have now been completed, the window for conducting the "before" macroinvertebrate samples has passed (with the possible exception of sites W-07 and S-08). However, it may still be possible to use macroinvertebrate assessments with an "upstream/downstream" approach to evaluate road crossings. In addition, the project team decided to limit the use of some survey techniques. The erosion pm network which was installed in cutslopes at site E-02 has been lost, probably in the course of road maintenance activities, and no follow-up measurements were possible. This has led us to believe that erosion pins may not be feasible for use at active new road sites in this type of a study, hence further use of this survey method was not pursued. At three of the sites where we had planned channel substrate transects, we opted to conduct streambank erosion surveys instead, deciding that they are likely more sensitive for assessing the type of disturbances which could result from harvest operations. Therefore, channel substrate transect surveys are only being used at site W-01. In addition, we decided not to conduct streambed stability surveys at as many sites as originally planned. The streambed stability survey technique is being used at two of the study sites to assess ground-based harvest practices in the vicinity of Type 4 and 5 streams. While we did not conduct as many of the above-mentioned surveys as had been planned when Interim Report No. 1 was published, we are using quantitative surveys in conjunction with qualitative techniques for 33% of our BMP

Table 3: Study Site Matrix Showing BMPs and Surveys Used

Site ID# & Name	Specific RMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro-invertebrat Survey
O-01	Tractor/Wheeled Skidding	X							X			X		
Salmon Creek	RMZ											X		
O-02	RLTA	X	X									X		
Walker Pass	Tractor/Wheeled Skidding	X	X									X		
O-03	Culvert Installation	X	X				X							
Jupiter Road	Road Drainage Design	X	X				X	X						
	Construction Techniques	X	X					X						
O-04: 9000 Mainline	Active Haul Road Maintenance		X							X	X			
"-05	Tractor/Wheeled Skidding	X	X	X								X		
Gunderson Creek	R M Z	X	X	X								X		
	Culvert Installation						X							
	Road Drainage Design						X	X						
	Construction Techniques							X						
O-06	Tractor/Wheeled Skidding	X	X									X		
Whale	R M Z	X	X									X		
W-01	RMZ	X	X			X						X		
Sears Creek	Tractor/Wheeled Skiddiog	X	X			X						X		
W-02	Tractor/Wheeled Skidding	X	X									X		
Nieman Creek	RMZ	X	X									X		
	Culvert Installation		X				X							
	Road Drainage Design		X				X	X						
	Construction Techniques		X					X						
w-03	Culvert Installation	X	X				X							
Train Whistle	Road Drainage Design	X	X				X	X						
	Construction Techniques	X	X					X						
W-04: 1600 Mainline	Active Haul Road Maintenance		X							X	X			
W-M	Culvert Installation	X	X				X							
Bus stop	Road Drainage Design	X	X				X	X						
	Construction Techniques	X	X					X						
W-05: Pot Pourri	R M Z	X	X									X	X	
W-m: Nigh, Dancer	R M Z	X	X									X	X	

Table 3: Study Site Matrix Showing **BMPs** and Surveys Used (cont.)

Site ID# & Name	Specific BMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro-invertebrate Survey
S-01: Camp One Road	Active Haul Road Maintenance		X							X	X			
S-02	Culvert Installation						X							
8 Road Unit 2	Road Drainage Design						X	X						
	Construction Techniques							X						
S-03	Culvert Installation						X							
Ohop Blowdown	Road Drainage Design						X	X						
	Construction Techniques							X						
S-04: Friday Creek II	RMZ		X									X	X	
S-05: Sundog	RLTA											X	X	
S-06	Tractor/Wheeled Skidding	X	X		X									
Big Wedge	RLTA	X	X		X									
S-07	RMZ	X	X									X	X	
Eleven 32	Tractor/Wheeled Skidding	X	X									X	X	
S-08	RMZ	X	X	X								X	X	
Kapowsin	Tractor/Wheeled Skidding	X	X	X								X	X	
S-09	RMZ	X	X	X								X	X	X
Simmons Creek	Tractor/Wheeled Skidding	X	X	X								X	X	X
N-01	Tractor/Wheeled Skidding	X	X									X		
Upper Shop	RLTA	X	X									X		
	Culvert Installation	X	X				X							
	Road Drainage Design	X	X				X	X						
	Construction Techniques	X	X					X						
N-02: Pilchuck Mainline	Active Haul Road Maintenance		X							X	X			
E-01	culvert Installation	X	X											
Fish Take Mine	Road Drainage Design													
	Construction Techniques	X	X											
	Tractor/Wheeled Skidding	X	X									X		
E-02	Culvert Installation	X	X	X			X							
Plesha Road	Road Drainage Design	X	X	X			X	X						
	Construction Techniques	X	X	X				X						
E-04	Tractor/Wheeled Skidding	X										X		
Green Canyon	RMZ											X		
E-05	Tractor/Wheeled Skidding											X		
Aspen Patch	RMZ											X		

Table 3: Study Site Matrix **Showing BMPs** and Surveys Used (cont.)

Site ID# & Name	Specific BMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro-invertebrate Survey
R-01	Tractor/Wheeled Skidding	X	X									X		
Cee Cee Ah	RMZ	X	X									X		
	Culvert Installation						X							
	Road Drainage Design						X	X						
	Contruction Techniques							X						
R-02	RMZ	X	X	X	X							X	X	
Muddy West	Tractor/Wheeled Skidding	X	X	X	X							X	X	
	Culvert Installation	X	X	X			X							
	Road Drainage Design	X	X	X			X	X						
	Construction Techniques	X	X	X				X						
R-03	RMZ	X	X	X								X	X	
Muddy East	Tractor/Wheeled Skidding	X	X	X								X	X	
R-04	RMZ	X	X									X	X	
Buck East	Tractor/Wheeled Skidding	X	X									X	X	
R-05	RMZ	X	X	X								X	X	
suck West	Tractor/Wheeled Skidding	X	X	X								X	X	
R-06	RMZ		X									X	X	
Middle	Tractor/Wheeled Skidding		X									X	X	
R-07	RMZ	X	X	X								X	X	
Sherry Creek	Tractor/Wheeled Skidding	X	X	X								X	X	
	Culvert Installation	X	X	X			X							
	Road Drainage Design	X	X	X			X	X						
	Construction Techniques	X	X	X				X						
R-08	RMZ	X	X									X	X	
Amazon	Tractor/Wheeled Skidding	X	X									X	X	

examples. This exceeds the 20% target given in the project study plan. The quantitative survey techniques include streambank erosion surveys, streambed stability surveys, channel substrate transects, runoff sampling, erosion pin networks, and macroinvertebrate sampling. In addition, the sediment routing surveys, road surface condition surveys, and amphibian surveys include some quantitative elements.

There have been a few study site changes as well. Site W-08 was dropped as an active haul road maintenance site because active log hauling on the road has ceased. Site R-01 may also be dropped from the study in the near future, because of delays in timber harvesting at this site. Delays in harvesting the timber at site W-07 may also result in its loss as a study site. Partly because of the budget cuts discussed above, we have not actively pursued replacements for these BMP examples.

A narrative description of each study site is provided in Appendix B. These descriptions provide an overview of the environmental setting for the study sites, summarize the forest practice activities, and describe how and where the surveys were used at each site.

FUTURE EFFORTS

Follow-up surveys will be conducted through the summer of 1995. During periods of high precipitation (late fall, winter, and early spring), field efforts will focus on active haul road maintenance. Additional examples of active haul road maintenance BMPs may be selected, depending on workload constraints. During the late spring through early fall period, we will focus our field efforts on new road construction and harvest practices. For selected sites which were harvested in 1993, low altitude aerial photography will be flown in 1994, once the ground is free of snow cover and solar angles are sufficiently high. These photos will be used for sediment routing surveys.

We envision the formation of work group(s) to assist in the development of BMP effectiveness decision criteria during the winter of 1994/95. After the last follow-up surveys are completed in July of 1995, we will make BMP assessments and prepare the draft final project report, which is scheduled for November of 1995. The final report on the project is scheduled for January 1996.

REFERENCES

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Rashin, E., J. Bell, and C. Clishe. 1993. Effectiveness of Forest Road and Timber Harvest BMPs with Respect to Sediment-related Water Quality Imoacts. Interim Report No. 1, TFW-WQ8-93-001. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program. Olympia, Washington.

APPENDIX A:
Best Management Practices Evaluated
(Excerpted from the Washington Forest Practices Rules and Regulations, Title 222 WAC)

WAC 222-24-025 Road Design.

*(5) ALL ROADS should be outsloped or ditched on the uphill side and appropriate surface drainage shall be provided by the use of adequate cross drains. ditches, drivable dips, relief culverts, water ban, diversion ditches, or other such structures demonstrated to be equally effective.

*(6) CROSS DRAINS, relief culverts, and diversion ditches shall not discharge onto erodible soils, or over fill slopes unless adequate outfall protection is provided.

*(7) INSTALL cross drains, culverts, water bars, drivable dips, or diversion ditches on all forest roads to minimize erosion of the mad bed, cut bank, and fill slope. or to reduce sedimentation of Type 1, 2, 3 or 4 Water. Cross drains are required in wetlands to provide for continued hydrologic connectivity. These drainage structures shall be installed at all natural drainages, all low points in the road gradient and spaced no wider than as follows:

Grade	Distance Westside	Distance Eastside
0 to 7%	1,000 ft.	1,500 ft.
8% to 15%	800 ft.	1,000 ft.
over 15%	600 ft.	800 ft.

More frequent culvert spacing or other drainage improvements are required where site specific evidence of peak flows or soil instability makes additional culverts necessary to minimize erosion of the road bed, ditches, cut bank, and fill slope to reduce sedimentation of Type 1, 2, 3 or 4 Waters, or within wetlands or to avoid unreasonable risk to public resources. See Part 5, Table 2 in the forest practices board manual for "Additional culvert spacing recommendations.' On request of the applicant. the department may approve less frequent drainage spacing where parent material (e.g. rock, gravel) or topography justify.

*(8) RELIEF CULVERTS installed on forest roads shall meet the following minimum specifications:

(a) Be at least 18 inches in diameter or equivalent in western Washington and 15 inches in diameter or the equivalent in eastern Washineton.

(b) Be installed sloping toward the outside edge of the mad at a minimum gradient of 3 percent.

*(9) DITCH DIVERSION. Where roadside ditches slope toward a Type 1, 2, 3 Water. or Tvne A or B Wetland for more than 300 feet and otherwise would discharge into the stream or wetland, divert the ditchwater onto the forest floor by relief culvert or other means at the first practical point.

WAC 222-24-030 Road Construction.

*(2) DEBRIS BURIAL.

(a) In permanent mad construction, do not bury:

(i) Loose stumps. logs or chunks containing more than 5 cubic feet in the load-bearing portion of the mad, except as puncheon across wetlands or for culvert protection.

(ii) Any significant amount of organic debris within the top 2 feet of the load-bearing portion of the mad. except as puncheon across wetlands or for culvert protection.

(iii) Excessive accumulation of debris or slash in any part of the load-bearing portion of the road fill, except as puncheon across wetlands or for culvert protection.

(b) In the cases where temporary roads are being constructed across known areas of unstable soils and where possible construction failure would directly impact waters, the requirements in (a), (i), (ii) and (ii) of this subsection shall apply, A temporary road is a roadway which has been opened for the purpose of the forest practice operation in question, and thereafter will be an inactive or abandoned road.

*(4) STABILIZE SOILS. When soil, exposed by road construction, appears to be unstable or erodible and is so located that slides, slips, slumps. or sediment may reasonably be expected to enter Type 1, 2, 3 or 4 Water and thereby cause damage to a public resource, then such exposed soil areas shall be seeded with grass, clover, or other ground cover, or be treated by erosion control measures acceptable to the department. Avoid introduction of nonnative plant species, as listed in the board manual. to wetlands and wetland management zones.

'(5) CHANNEL CLEARANCE. Clear stream channel of all debris and slash generated during operations prior to the removal of equipment from the vicinity, or the winter season, whichever is rust.

*(6) DRAINAGE.

(a) All required ditches, culverts, cross drains, drainage dips. water bars, and diversion ditches shall be installed concurrently with the construction of the roadway.

(b) Uncompleted mad construction to be left over the winter reason or other extended periods of time shall be drained by outsloping or cross draining. Water bars and/or dispersion ditches may also be used to minimize eroding of the construction area and stream siltation. Water movement within wetlands must be maintained.

*(7) MOISTURE CONDITIONS. Construction shall be accomplished when moisture and soil conditions are not likely to result in excessive erosion and/or soil movement. so as to avoid damage to public resources.

*(8) END HAUL/SIDECASTS. End haul or overhaul construction is required where significant amounts of sidecast material would rest below the 50-year flood level of a Type 1, 2, 3, or 4 Water, within the boundary of a Type A or Type B Wetland or wetland management zones or where the department determines there is a potential for mass soil failure from overloading on unstable slopes or from erosion of side cast material causing damage to the public resources.

*(9) WASTE DISPOSAL. When spoil, waste and/or other debris is generated during construction, this material shall be deposited or wasted in suitable areas or locations and be governed by the following:

(a) Spoil or other debris shall be deposited above the 50-year flood level of Type 1, 2, 3, or 4 Waters or in other locations so as to prevent damage to public resources. The material shall be stabilized by erosion control measures as necessary to prevent the material from entering the waters.

(b) All spoils shall he located outside of Type A and Type B Wetlands and their wetland management zones. Spoils shall not be located within the boundaries of forested wetlands without written approval of the department and unless a less environmentally damaging location is unavailable. No swil area greater than 0.5 acre in size shall be allowed within wetlands.

*(c) Truck roads, skid trails, and tire trails shall be outsloped or cross drained uphill of landings and the water diverted onto the forest floor away from the toe of any landing fill.

*(d) Landings shall be sloped to minimize accumulation of water on the landing.

*(e) Excavation material shall not be sidecast where there is high potential for material to enter Type A or B wetlands or wetland management zones or below the ordinary high-water mark of any stream or the 50-year flood level of Type 1, 2, 3, or 4 Water.

*(f) All spoils shall be located outside of Type A and Type B Wetlands and their wetland management zones. Spoils shall not be located within the boundaries of forested wetlands without written approval of the department and unless a less environmentally damaging location is unavailable. No spoil area greater than 0.5 acre in size shall he allowed within wetlands.

WAC 222-24-040 Water Crossing Structures.

*(2) CULVERT INSTALLATION: AU permanent culverts installed in forest roads shall be of a size that is adequate to carry the 50-year flood or the road shall be constructed to provide erosion protection from the 50-year flood waters which exceed the water-carrying capacity of the drainage structure. Refer to Part 5 "Recommended culvert sizes' in the forest practices board manual for the size of permanent culverts recommended for use in forest roads. If the department determines that because of unstable slopes the culvert size shown on that table is inadequate to protect public resources, it may require culvert sizes in accordance with the nomograph (chart) contained in Part 5 of the forest practices board manual or with other generally accepted engineering principles.

(a) No permanent culverts shall be installed that are smaller than:

(i) 24 inches in diameter or the equivalent for anadromous fish streams or wetlands where anadromous fish are present.

(ii) 18 inches or the equivalent for resident game fish streams.

(iii) 18 inches or the equivalent for all other water or wetland crossings in western Washington.

(iv) 15 inches or the equivalent for all other water or wetland crossings in eastern Washington.

(b) The alignment and slope of the culvert shall parallel the natural flow of the stream whenever possible.

(c) When fish life is present, construct the bottom of the culvert at or below the natural stream bed at the inlet and outlet.

(d) Terminate culverts on materials that will not readily erode, such as riprap, the original stream bed (ii stable), or other suitable materials.

(e) If water is diverted from its natural channel. return this water to its natural stream bed via culvert, flume, spillway, or the equivalent.

(f) When flumes, downspouts, downfall culverts, etc., an used to Protect till slopes or to return water to its natural courses, the discharge point shall be protected from erosion by: (i) Reducing the velocity of the water, (ii) use of rock spillways, (ii) riprap, (iv) splash plates, or (v) other methods or structures demonstrated to be equally effective.

(g) Stream beds shall be cleared for a distance of SO feet upstream from the culvert inlet of such slash or debris that reasonably may be expected to plug the culvert.

(h) The entrance of all culverts should have adequate catch basins and headwalls to minimize the possibility of erosion or fill failure.

'(3) CULVERTS IN ANADROMOUS FISH STREAMS. In addition to the requirements of subsection (2) of this section, in streams used by anadromous fish:

(a) Culverts shall be either open bottomed or have the bottom covered with gravel and installed at least 6 inches below the natural stream bed at the inlet and outlet.

(b) Closed bottom culverts shall not slope more than 1/2 percent; except as provided in (e) of this subsection; open bottom culverts shall not slope more than the natural slops of the stream bed.

(c) Where multiple culverts are used, one culvert shall be at least 6 inches lower than the other(s).

(d) Culverts shall be set to retain normal stream water depth throughout the culvert length. A downstream control may be required to create pooled water back into the culvert and to insure downstream stream bed stability.

(e) Closed bottom culverts. set at existing stream gradients between 1/2 percent and 3 percent slope shall be designed with baffles for water velocity control, or have an approved designed fishway.

(f) The department, after consultation with the departments of fisheries and wildlife. shall impose any necessary limitations on the time of year in which such culverts may be installed to prevent interference with migration or spawning of anadromous fish.

(g) Any of the requirements in (a) through (f) of this subsection may be superseded by a hydraulic project approval.

*(4) TEMPORARY WATER CROSSINGS.

(a) Temporary bridges and culverts, adequate to carry the highest anticipated flow in lieu of carrying the 50-year flood, may be used:

(i) In the westside region if installed after June 1 and removed by September 30 of the same year.

(ii) In the eastside region if installed after the spring runoff and removed prior to the snow buildup which could feed a heavy runoff.

(iii) At other times, when the department and applicant can agree to specific dates of installation and removal.

(b) Temporary bridges and culverts shall be promptly removed upon completion of use, and the approaches to the crossing shall be water barred and stabilized at the time of the crossing removal.

(c) Temporary wetland crossings shall be abandoned and restored based on a mitten plan approved by the department prior to construction.

WAC 222-24-050 Road Maintenance.

*(2) ACTIVE ROADS. An active road is a forest road being actively used for hauling of logs, pulpwood, chips, or other major forest products or rock and other mad building materials. To the extent necessary to prevent damage to public resources, the following maintenance shall be conducted on such roads:

(a) Culverts and ditches shall be kept functional.

(b) Road surface shall be maintained as necessary to minimize erosion of the surface and the subgrade.

(c) During and on completion of operations, mad surface shall be crowned, outsloped, or water barred and berms removed from the outside edge except those intentionally constructed for protection of fills.

*(4) ADDITIONAL CULVERTS/MAINTENANCE. If the department determines based on physical evidence that the above maintenance has been or will be inadequate to protect public resources and that additional measures will provide adequate protection it shall require the landowner or operator to either elect to:

(a) Install additional or larger culverts or other drainage improvements as deemed necessary by the department; or

(b) Agree to an additional mad maintenance program. Such improvements in drainage or maintenance may be required only after a field inspection and opportunity for an informal conference.

WAC 222-30-020 Harvest Unit Planning and Design.

*(3) WESTERN WASHINGTON RIPARIAN MANAGEMENT ZONES. These zones shall be measured horizontally fmm the ordinary high-water mark of Type 1, 2 or 3 Water and extend to the line where vegetation changes from wetland to upland plant community, or to the line required to lease sufficient shade as required by WAC 222-30-040. whichever is greater, but shall not be less than 25 feet in width nor more than the maximum widths described in (c) of thii subsection, provided that the riparian management zone width shall be expanded as necessary to include wetlands or ponds adjacent to the stream. When the riparian management zone overlaps a Type A or B Wetland or a Wetland Management Zone. the requirement which best protects public resources shall apply.

(a) Harvest units shall be designed so that felling, bucking, yarding or skidding, and reforestation can be accomplished in accordance with these regulations, including those regulations relating to stream bank integrity and shade requirements to maintain stream temperature. Where the need for additional actions or restrictions adjacent to waters not covered by the following become evident, WAC 222-12-050 and 222-12-060 may apply.

(b) When requested in writing by the applicant, the department shall assist in preparation of an alternate plan for the riparian management zone.

(c) Within the riparian management zone, there shall be trees left for wildlife and fisheries habitat as provided for in the chart below. Fifty percent or more of the trees shall be live and undamaged on completion of the harvest. The leave trees shall be randomly distributed where feasible; some clumping is allowed to accommodate operational considerations. The number. size, species and ratio of leave trees, deciduous to conifer. is specified by the bed material and average width of the water type within the harvest unit. Trees left according to (d) of this subsection may be included in the number of required leave trees in this subsection.

WATER TYPE/ AVERAGE WIDTH	RMZ MAXIMUM WIDTH	RATIO OF CONIFER TO DECIDUOUS/ MINIMUM SIZE LEAVE TREES	# TREES/1000 FT. EACH SIDE	
			GRAVEL/ COBBLE <10" DIAMETER	BOULDER/ BEDROCK
1 & 2 water 75' & over	100'	represen-tative of stand	50 trees	25 trees
1 & 2 Water under 75'	75'	represen-tative of stand	100 trees	50 trees
3 Water 5' & over	50'	2 to 1/ 12" or next largest available	75 tree*	25 trees
3 water less than 5'	25'	1 to 1/ 6" or next largest available	25 trees	25 trees

'Or next largest available' requires that the next largest trees to those specified in the rule be left standing when those available an smaller than the sizes specified. Ponds or lakes which are Type 1, 2 or 3 Waters shall have the same leave tree requirements as boulder/bedrock streams.

(d) For wildlife habitat within the riparian management zone, leave an average of 5 undisturbed and uncut wildlife trees per acre at the ratio of 1 deciduous tree to 1 conifer tree equal in size to the largest existing trees of those species within the zone. Where the 1 to 1 ratio is not possible. then substitute either species present. Forty percent or more of the leave trees shall be live and undamaged on completion of harvest. Wildlife trees shall be left in clumps whenever possible.

(e) When 10 percent or more of the harvest unit lies within any combination of a riparian management zone of Type I, 2 or 3 Waters or a wetland management zone and the harvest unit is a clearcutting of 30 acres or less, leave not less than 50 percent of the trees required in (c) of this subsection.

*(4) EASTERN WASHINGTON RIPARIAN MANAGEMENT ZONES. These zones shall be measured horizontally from the ordinary high-water mark of Type 1, 2 or 3 Waters and extend to the line where vegetation changes from wetland to upland plant community, or to the line required to leave sufficient shade as required by WAC 222-30-040, whichever is greater, but shall not be less than the minimum width nor more than the maximum widths described in (c) of this

subsection, provided that the riparian management zone width shall be expanded as necessary to include wetlands or ponds adjacent to the stream. When the riparian management zone overlaps a Type A or B Wetland or a Wetland Management Zone, the requirement which best protects public resources shall apply.

(a) Harvest units shall be designed so that felling, bucking, yarding or skidding, and reforestation can be accomplished in accordance with these regulations, including those regulations relating to stream bank integrity and shade requirements to maintain stream temperature. When the need for additional actions or restrictions adjacent to waters not covered by the following become evident, WAC 222-12-050 and 222-12-060 may apply.

(b) When requested in writing by the applicant, the department shall assist in preparation of an alternate plan for the riparian management zone.

(c) Within the riparian management zone, then shall be trees left for wildlife and fisheries habitat as provided for below. Fifty percent or more of the trees shall be live and undamaged on completion of the harvest. The leave trees shall be randomly distributed where feasible; some clumping is allowed to accommodate operational considerations.

(i) The width of the riparian management zone shall be based on the adjacent harvest type as defined in WAC 222-16- 010(33) Partial cutting. When the adjacent unit harvest type is:

Partial cutting - The riparian management zone width shall be a minimum of 30 feet to a maximum of 50 feet on each side of the stream.

Other harvest types - The riparian management zone shall average 50 feet in width on each side of the stream with a minimum width of 30 feet and a maximum of 300 feet on each side of the stream.

(ii) Leave tree requirements within the riparian management zones of Type I, 2 or 3 waters:

(A) Leave all trees 12 inches or kss in diameter breast height (dbh); and

(B) Leave all wildlife reserve trees within the riparian management zone where operations in the vicinity do not violate the state safety regulations (chapter 29654 WAC and Chapter 49.17 RCW administered by department of labor and industries, safety division); and

(C) Leave 16 live conifer trees/ acre between 12 inches dbh and 20 inches dbh distributed by size. as representative of the stand; and

(D) Leave 3 live conifer trees/acre 20 inches dbh or larger and the 2 largest live deciduous trees/acre 16 inches dbh or larger. When these deciduous trees do not exist. and where 2 wildlife reserve trees/acre 20 inches or larger do not exist, substitute 2 live conifer trees/acre 20 inches dbh or larger. If live conifer trees of 20 inches dbh or larger do not exist within the riparian management zone, then substitute the 5 largest live conifer trees/acre; and

(E) Leave 3 live deciduous trees/acre between 12 inches and 16 inches dbh where they exist.

(iii) Minimum leave tree requirements per acre for Type 1, 2 and 3 Waters. Trees left for (c)(ii) of this subsection shall be included in the minimum counts.

(A) On streams with a boulder/bedrock bed, the minimum leave tree requirements shall be 75 trees/acre 4 inches dbh or larger.

(B) On streams with a gravel/cobble (less than 10 inches diameter) bed, the minimum leave tree requirement shall be 135 trees/acre 4 inches dbh or larger.

(C) On lakes or ponds the minimum leave tree requirement shall be 75 trees/acre 4 inches dbh or larger.

Note: (See the Forest Practices Board Manual for assistance in calculating trees/acre and average RMZ widths.)

(d) When 10 percent or more of the harvest unit lies withii any combination of a riparian management zone of Type 1, 2 or 3 Waters or wetland management zone and either the harvest unit is a clearcutting of 30 acres or less or the harvest unit is a partial cutting of 80 acres or less, leave not less than 50 percent of the trees required in (c) of this subsection. (See WAC 222-16-010(33) Partial cutting.)

*(4) DEADFALLS. Logs firmly embedded in the bed or bank of Type 1, 2. 3 or 4 Waters shall not be removed or unnecessarily disturbed without hydraulic project approval of the departments of fisheries or wildlife.

*(5) MOISTURE CONDITIONS. Tractor and wheeled skidders shall not he used on exposed erodible soils or hydric (wetland) soils when soil moisture content is so high that unreasonable soil compaction, soil disturbance. or wetland, stream. lake or pond siltation would result.

(6) PROTECTION OF RESIDUAL TIMBER. Reasonable care shall be taken to minimize damage from skidding to the stems and root systems of residual timber and to young reproduction.

*(7) SKID TRAIL CONSTRUCTION.

(a) Skid trails shall be kept to the minimum feasible width.

(b) Reasonable care shall be taken to minimize the amount of sidecast required and shall only be permitted above the so-year flood level.

(c) Skid trails shall be outsloped where practical. hut be insloped where necessary to prevent logs from sliding or rolling downhill off the skid trail.

*(8) SKID TRAIL MAINTENANCE. Upon completion of use and termination of seasonal use, skid trails on slopes in exposed soils shall be water barred where necessary to prevent soil erosion.

*(9) SLOPE RESTRICTIONS. Tractor and wheeled skidders shall not be used on slopes where in the opinion of the department this method of operation would cause unnecessary or material damage to a public resource.

*(5) RIPARIAN LEAVE TREE AREAS. The department will require trees to be left along Type 4 Water where such practices are necessary to protect public resources. Where such practices are necessary leave at least 2.5 conifer or deciduous trees, 6 inches in diameter or larger, on each side of every 1000 feet of stream length within 25 feet of the stream. The leave trees may be arranged to accommodate the operation.

WAC 222-30-030 Stream Bank Integrity.

*In the riparian management zone along all Type 1, 2 and 3 Waters, the operator shall:

(1) AVOID DISTURBING BRUSH and similar understory vegetation;

(2) AVOID DISTURBING STUMPS and root systems and any logs embedded in the bank;

(3) LEAVE HIGH STUMPS where necessary to prevent felled and bucked timber from entering the water;

(4) Leave trees which display large root systems embedded in the bank.

[Statutory Authority: RCW 76.09.040. 87-23-036 (Order 535). §222-30-030, filed 11/16/87, effective 1/1/88; Order 263, §222-30-030, filed 6/16/76.]

WAC 222-30-070 Tractor and Wheeled Skidding Systems.

*(1) TYPED WATERS AND WETLANDS.

(a) Tractor and wheeled skidders shall not bc used in Type 1, 2 or 3 Water, except with approval by the department and with a hydraulic project approval of the departments of fisheries or wildlife.

(b) In order to maintain wetland water movement and water quality, and to prevent soil compaction, tractor or wheeled skidders shall not be used in Type A or B Wetlands without prior mitten approval of the department.

(c) Within all wetlands. tractors and wheeled skidder systems shall be limited to low impact harvest systems. Ground based logging systems operating in wetlands shall only be allowed within wetlands during periods of bw soil moisture or frozen soil conditions.

(d) Skidding across any flowing Type 4 Water shall be minimized and when done. temporary stream crossings shall be used, if necessary, to maintain stream bed integrity.

(e) Whenever skidding in or across any type water, the direction of log movement between stream banks shall be as close to right angles to the stream 'channel as is practical.

'(2) RIPARIAN MANAGEMENT ZONE.

(a) Logging will be permitted within the zone. However. any use of tractors, wheeled skidders. or other yarding machines within the zone must be as described in an approved forest practices application or otherwise approved in writing by the department.

(b) Where skidding in or through the riparian management zone is necessary, the number of skidding routes through the zone shall be minimized.

(c) Logs shall be skidded so as to minimize damage to leave trees and vegetation in the riparian management zone, to the extent practical and consistent with good safety practices.

*(3) WETLANDS MANAGEMENT ZONES.

(a) Logging will be permitted within wetland management zones.

(b) Where feasible logs shall be skidded at least with one end suspended from the ground so as to minimize soil disturbance and damage to leave trees and vegetation in the wetland management zone.

(c) Tractors. wheeled skidders, or other ground based harvesting systems shall not be used within the minimum WMZ width without written approval of the department.

APPENDIX B:
Study Site Descriptions

APPENDIX B: Study Site Descriptions

Notes on Information Sources: The following study site descriptions provide general information on each study site. Included in these descriptions is information on the geologic setting of each site. The source of information for surface geology are the 1: 100,000 scale geologic quadrangle maps published by the Department of Natural Resources (DNR) and/or the U.S. Geological Survey (USGS). Soils classifications and management interpretations (e.g. disturbed slope stability ratings, cutslope/fill/sidecast hazard, and erosion potential) are taken from the State Soil Survey maps and reports published by the Department of Natural Resources. Soil mapping units are identifiedby listing the soil series followed by slope phases. Slope hazard categories given in the descriptions are based on field measurements and the hazard classification scheme developed for this study, as described in the body of the report.

Stream order, as given in the study site descriptions, is based on the Strahler method using 1:24,000 scale USGS quadrangle topographic maps; streams not shown as blue lines on such maps are classified as zero order, even though they may be shown as lines on DNR water type maps. Water type, as defined in WAC 222-16-030 (forest practice rules and regulations), is based on DNR water type maps and/or approved forest practices applications (FPAs) as well as field observations. If field observations of physical criteria or fish presence conflict with water type maps and/or FPAs, this is noted in the descriptions. Stream channel morphology classifications are based on our field surveys, with study reaches classified according to the scheme of Montgomery and Buffmgton (1993). Average channel gradients are based on weighted averages of clinometer readings taken within study reaches. Valley form is based on the simplified scheme used in our channel condition survey methodology (see Rashin et. al., 1993). References to left or right stream banks are based on the observer facing downstream.

The area of harvest and length of road construction are generally taken from FPAs, supplemented by field observations. Dates of activities were supplied by landowner representatives in most cases. Survey techniques referred to in the descriptions are described in detail in the first interim report (Rashin et.al., 1993). In cases where amphibian surveys are referred to, these surveys are conducted as part of separate, co-located research projects by researchers from the University of Washington and Eastern Washington University. The amphibian surveys referred to for western Washington study sites are those specifically evaluating effects on stream amphibians. For eastern Washington study sites we are referring to riparian amphibian surveys; results from these surveys will be used to assess water quality BMP effectiveness to the extent that they provide information on effects to amphibiis that are related to their use of aquatic habitats.

Olympic Physiographic **Region**

Site O-01: Salmon Creek

The **Salmon** Creek site is a harvest practice located in the western portion of Jefferson County in the Olympic physiograpbic region. The underlying geology is glacial deposits with areas of basalt and mudflow **breccia**. Soils are mapped as Alderwood gravelly sandy loam with two phases (0-15 % and 30-50 % slopes) along the **left** bank tributaries to **Salmon** Creek and **Salmon** Creek itself. Soils for the right bank tributaries to **Salmon** Creek are Alderwood gravelly loam, O-1556 slopes. The disturbed soil slope stability rating for the O-15 % slope phase is stable, with an unstable rating for the 30-50 % slope phase. The **cutbank/fill/sidecast** hazard for the 0-15 % slope phase is slight, with the 30-50 % slope phase being rated as **moderate**. The erosion potential ratings are low and medium, respectively, for the O-15 % and 30-50 % slope phases. The harvest **BMP** slope hazard category is high due to steep **inner** gorges along the creeks. Valley side slopes range from 63 % to 106 % along **Salmon** Creek, and are moderately to very steep along its tributaries as well. **Salmon** Creek bisects the harvest unit along its long axis in a V-shaped valley. It is a 3rd order, Type 2 stream and is a major tributary to Discovery Bay on the Strait of Juan De Fuca near the **town** of **Uncas**. There are three left bank tributaries along Sahnon Creek within the harvest unit. The tributary along the western boundary of the unit is a zero order Type 4, the one in the middle of the unit is a 2nd order Type 3 stream, and a third tributary is a zero order Type 5 that is not depicted on **DNR** Water Type maps. Along the right bank to Sahnon Creek is one 2nd order Type 3 tributary that enters **Salmon** Creek in the center of the harvest unit.

Forest practices at the site include a 21 hectare (ha) **clearcut** using ground-based harvesting methods. Harvest was completed by September of 1992. An **RMZ** was established along the Type 2 and 3 waters, with selective logging occurring within the **inner** gorges in some areas. Portions of the **unit** were harvested by feller-buncher.

The **BMP** selected for **evaluation** is the skidder logging adjacent to the **RMZs** along the Type 2 and 3 waters as well as logging in the vicinity of the Type 5 stream. Sediment routing surveys, erosion pin networks of skid trails, and photo point network surveys of skid trails have been conducted.

Site O-02: Walker Pass

This site is a harvest practice located in the eastern portion of Jefferson County in the Olympic physiographic region. The underlying geology is Eocene marine basalt flow and mudflow breccia. The soils have not been mapped for this area. Due to lack of soil mapping no soil hazard interpretations are available. The slope hazard category for the harvest is moderate. The portion of the unit being evaluated for BMP effectiveness contains two zero order Type 5 tributaries and one zero order Type 4 tributary to Spencer Creek, which flows into Hood Canal near Putali Point. The Type 4 stream has a step-pool channel morphology. The channel gradient varies from 14% to 25%

Forest practices at the site included two harvest methods, ground-based and cable-yarding, for the 10 ha clearcut. The ground-based harvest occurred adjacent to the RLTA along the Type 4 stream and across the two Type 5 streams. The two Type 5 streams were not, buffered. The ground-based harvest was completed in October of 1992.

The BMPs selected for evaluation were the ground-based harvesting with an RLTA along the Type 4 stream, and the ground-based harvesting around the Type 5 streams without RLTAs. Three study reaches on the Type 4 stream have been established. There are two treatment reaches within the unit, one above a major skid trail crossing and the other directly below it, and a control reach upstream of the unit boundary. Channel condition and photo point network surveys were conducted on these three study reaches in October of 1992. In addition, a sediment routing survey was conducted in the vicinity of the Type 4 and Type 5 streams in June of 1993. In October of 1993 the three study reaches were resurveyed using channel condition and photo point network surveys.

Site O-03: Jupiter Road

The Jupiter Road site is a new road construction practice located along the eastern edge of Jefferson County in the Olympic physiographic region. The underlying geology is Eocene marine basalt flow and mudflow breccia. Soils consist of Triton-Hoodsport complex, 30-70% slopes. The disturbed soil slope stability rating is unstable with a cutbank/fill/sidecast hazard rating of severe and a high hazard rating for soil erosion potential. The slope hazard category for the road construction is high. The valley side slopes at the stream crossing range from 64% to 72%. The new road crosses a 1st order, Type 5 and a zero order Type 5, both tributaries to the Dosewallips River which flows into Hood Canal at the town of Brinnon Flats. The 1st order stream appears to meet the criteria for a Type 4 stream based on its physical characteristics, however it is depicted as a Type 5 on DNR Water Type maps and the FPA. The channel morphology is cascade. Average active channel width is about 6 m, with an average channel gradient of 44 % .

The forest practice is 0.4 km of new road construction along steep slopes. The road crosses both streams. The road construction was completed by September 1992.

The BMPs selected for evaluation were the road drainage design, culvert installation and construction techniques. Three study reaches were established in September of 1992 on the larger stream. Channel condition surveys were conducted on two treatment reaches downstream of the road crossing and one control reach upstream of the road crossing. Photo point network surveys were conducted in October of 1992 on the upstream control and one treatment reach, and a culvert condition survey of the entire new road segment was conducted. In August of 1993 a cutbank/fillslope survey was conducted. Subsequent follow up surveys were conducted in October of 1993 for all three channel condition surveys, the culvert condition survey, and photo point network surveys. Follow up surveys will continue through mid-1995.

Site O-04: 9000 Mainline

The 9000 Mainline site is an active haul road located in western Clallam County in the Olympic physiographic region. Underlying geology is sandstone and siltstone. Soils consist of Ozette silt loam, 5-35 % slopes. The slope stability rating is unstable for disturbed soils. The hazard rating for cutbank/fill/sidecast is moderate with a low hazard rating for erosion potential. The slope hazard category is moderate. The haul road crosses a zero order, Type 5 tributary to the Hoko River which flows into the Strait of Juan De Fuca at Kydaka Point. This stream appears to meet the criteria for a Type 3 Water based on its physical characteristics, however, it is shown as a Type 5 on the DNR Water Type map. The channel morphology is step-pool. The average active channel width is 2.3 m below the road and 6 m above the road with average channel gradients of 5 % and 3 % for the upstream and downstream, respectively.

The forest practices being evaluated at the site is mainline haul road maintenance. Maintenance schedules vary according to traffic volume, weather conditions, and road-bed integrity. It is anticipated that maintenance activities will occur periodically throughout the duration of the project.

Channel condition surveys have been conducted both up and down stream of the road crossing. In January of 1994 a runoff sampling took place along with road surface condition survey. Although a rainfall-runoff event was expected and we proceeded with sampling, the event never materialized, and our raingage and stream stage recorder revealed only a trace of rain and a receding hydrograph during the sampling period.

Site O-05: Gunderson Creek

The Gunderson Creek site is a harvest and new road construction practice located in western Clallam county in the Olympic physiographic region. The underlying geology consists of sandstone, siltstone, and glacial drift deposits. The soil is Snahopish very gravelly loam, 35-75 % slopes. Disturbed soil slope stability rating is unstable with a severe hazard rating for cutbank/fill/sidecast road construction and a high hazard for soil erosion potential. The harvest and road BMP slope hazard categories are high due to steep inner gorges along the streams. Within the harvest unit are 5 zero order tributaries to Gunderson Creek, a 2nd order Type 2 stream which enters the Soleduck River downstream of the unit. An additional zero order stream is located in the area of new road construction that provides access to the site. Of the 5 zero order streams, in the harvest unit, two are Type 3, 2 are Type 4, and one is Type 5. The zero order stream outside the harvest unit is a Type 5. The channel morphology for the two zero order streams selected for the study are step-pool with either U-shaped or V-shaped valley forms. These two study streams have average channel gradients of about 10%.

The forest practice includes a 45 ha clearcut with 1.1 km of new road construction. Of the 1.1 km of new road construction, 0.8 km of it is located within the harvest unit itself. Gunderson Creek forms the southeastern boundary of the harvest unit. The southern boundary of the unit is formed by the Soleduck River. The zero order streams flow across the unit from west to southeast to Gunderson Creek. The two Type 3 streams have RMZs established on them with the Type 4s and 5s having no buffer. RMZs also exist along the Gunderson Creek and the Soleduck River. The road traverses across the slope and parallels Gunderson Creek. The road construction was completed in October of 1992. The harvest was completed January of 1994.

The harvest BMPs selected for evaluation include the RMZ along the Type3 stream in the northern portion of the site and the harvest along the non-buffered Type 4 stream in the middle of the unit. Three study reaches were established. Two treatment reaches have been established on two streams within the unit, and a control reach is located upstream of the unit boundary. The control reach is located on the same Type 3 stream that contains one of the treatment reaches. The landowner of the site that contains the control reach has initiated a harvest of the site for 1994. Unfortunately, this will compromise the control function of this reach if the harvest proceeds this year. However, there will be an RMZ left along the reach, so some level of comparison with the unbuffered Type 4 may be possible. Preliminary surveys conducted in 1993 before the harvest include channel condition, streambank erosion, and photo point network surveys on all three study reaches. New road construction BMPs under evaluation include road drainage design, culvert installation, and road construction techniques. Culvert condition and cutbank/fillslope surveys were conducted in early July of 1993. Future surveys planned include a sediment routing survey to be conducted in the spring of 1994. Follow up surveys will continue through the summer of 1995.

Site O-06: Whale Site

The Whale Site is a harvest unit located in western Clallam County in the Olympic physiographic region. The underlying geology is glacial drift deposits. The soils consist of Queets silt loam, 0-5% slopes. The disturbed soil stability rating is stable. The hazard rating for cutbank/fill/sidecast is given as not applicable with a low hazard rating for erosion potential. The harvest slope hazard category is moderate. The Soleduck River, Type 1+, makes a large U-shaped bend which comprises the unit's boundary on three sides. A zero order, Type 3 stream, which is a "wall-based" channel associated with the Soleduck, is located within the unit. This stream was not shown on the DNR water type maps but was depicted on the landowner's FPA. The Soleduck River meets the Bogachiel River to form the Quillayute River that then empties into the Pacific Ocean at the town of La Push. The channel morphology for the Type 3 stream is plane-bed. Its average active channel width is 2 m with an average channel gradient of 2%

The forest practice consists of a 25 ha clearcut with 0.4 km of new road construction. A 60 m RMZ was established along the Soleduck, with no removal of trees proposed from within the maximum RMZ. The unit lies predominantly on an old river terrace. The Type 3 stream flows into the 60 m RMZ with a small reach being located within the harvesting area. The harvest is a skidder and shovel operation, which was completed in December 1993.

The BMPs selected for evaluation were the skidder harvest adjacent to the Type 3 stream and its RMZ. One study reach was selected in the Type 3 stream to serve as our treatment reach. To date we have conducted channel condition and photo point network surveys on this reach. A suitable site-specific control reach was not found for this site. The instream surveys will be supplemented with a sediment routing survey to be conducted in the late spring or summer of 1994. Follow up surveys will continue through the summer of 1995.

Wiiapa Hills Physiographic Region

Site W-01: Sears Creek

The Sears Creek site is a harvest practice located in the southwestern comer of Lewis County about a mile due north of the town Wildwood. The underlying geology of the site is Eocene-aged marine sedimentary rocks consisting of siltstone, claystone, shale, and sandstone. Soils are Melbourne loam 8-15 % slopes and Buckpeak silt loam, 30-65 % slopes. Both soil types have a disturbed slope stability rating of stable, and moderate hazard a rating for cutbank/fill/sidecast road construction. Erosion potential for the two series are rated as medium. The BMP slope hazard category for the harvest unit is moderate. Sears Creek, a 2nd order Type 3 tributary to the South Fork Chehalis River, is located on the southern boundary of the harvest unit. Sears Creek has a riffle-pool channel morphology. Active channel width is 3.3 m with an average stream channel gradient of 1%.

Forest practices at the site include a 28 ha clear cut using ground-based as well as cable yarding methods. The unit lies on the north side of Sears Creek. An RMZ was established along Sears Creek with harvest adjacent to it using rubber-tired and tracked skidders. The harvest was completed in February of 1994.

BMPs selected for evaluation include the RMZ with adjacent ground-based harvesting. Two study reaches have been established along Sears Creek. The treatment reach was established within the RMZ and a control reach established upstream of the harvest unit boundary. Surveys conducted to date on the two reaches include channel condition, channel substrate transects, and photo point networks. Future surveys planned include sediment routing surveys along the RMZ, as well as follow-up surveys to those already conducted.

Site W-02 : Neiman Creek

The Neiman Creek site consists of a harvest unit with new road construction and is located in western Lewis County in the Willapa Hills physiographic region. The underlying geology of the site is Eocene marine sedimentary rock consisting of siltstone, claystone, shale, and sandstone. Soils are Melbourne loam along slopes of 15-30% and Buckpeak silt loam in areas of 3060% slopes. The disturbed slope stability for the Melbourne loam 1530% slope phase is unstable, while the Buckpeak soils are rated as stable. Both soil types have a moderate hazard rating for cutbank/fill/sidecast road construction, and a medium hazard rating for erosion potential. The slope hazard category, based on maximum valley side slopes, for both the harvest unit and the new road construction BMPs are moderate. Valley side slopes range from 5% to 21%. A 1st order tributary to the South Fork Chehalis River, Neiman Creek flows along the eastern boundary of the harvest unit with a zero order Type 5 stream located within the harvest boundary. Neiman Creek is depicted as a Type 4 on the DNR Water Type map, but was treated with an RMZ during the logging of the site. It appears to meet the physical criteria (e.g. stream width and gradient) for a Type 3 water. The Type 5 stream enters Neiman Creek within our study reach. The tributary was not buffered by either an RLTA or RMZ and was found to have a deeply incised channel along portions of its length. Neiman Creek flows through a series of old and recently active beaver dams that have formed a palustrine emergent wetland along it's flood plain. Channel morphology is classified as regime with a wide-alluviated valley form, and an average channel gradient of 1%.

Forest practices at this site include a 32 ha clear cut with 2.2 km of new road construction: Of the 2.2 km of road construction, approximately 1.1 km are within the harvest unit itself. The harvest took place along the west bank of Neiman creek with the new road accessing the site from the east. A 16 m temporary bridge was installed over Neiman Creek. An RMZ, with ground-based harvesting adjacent to it, was established along the west bank of Neiman Creek. This harvest was completed in February of 1994. Road construction was completed in the fall of 1993. The temporary bridge is to be removed by September 30, 1994.

The BMPs selected for evaluation are the RMZ with adjacent ground-based harvesting and new road construction. Three study reaches along Neiman Creek have been established. We have surveyed two treatment reaches, one along the RMZ above the temporary bridge and one downstream of the bridge, and a control reach upstream of the harvest unit boundary. Channel Condition surveys have been conducted for both treatment reaches and the control reach. Photo point networks have been constructed for the treatment reach upstream of the bridge and the control reach. In addition, cutbank/fillslope and culvert condition surveys have been conducted on the new road construction in the vicinity of the Neiman Creek crossing. Future surveys planned for spring and summer of 1994 and 1995 will include sediment routing surveys along the Type 5 stream and the RMZ, as well as follow-up surveys to those already conducted.

Site W-03: Train Whistle

This site is located in the north central area of Cowlitz County in the Wiipa Hills physiographic region. Underlying geology consists of upper Eocene volcaniclastic sedimentary and volcanic rock members of the Goble volcanics. Soils are predominantly Olympic gravelly silt loam, 30-65 % slopes. The disturbed soil slope stability rating is stable, with soil hazard ratings of moderate and medium, respectively, for cutbank/fill/sidecast road construction and erosion potential. The BMP slope hazard category for the road construction is high. Our study site contains one zero order and one 1st order stream, which are tributaries to Mulholland Creek which flows into the Coweeman River. These streams are depicted as Type 5s on the DNR Water Type map and on the FPA, however, they appear to meet the physical criteria for Type 4 Waters. One study stream has channel morphology of step-pool and the other has a cascade morphology. Channel gradients are 28-3 1% and active channel widths are about 2 m.

Approximately 6 km of road was constructed at this site. Approximately 2 km involved reconstruction of an old existing road while the remaining 4 km was new road construction. Conditions for the FPA included no sidecast road construction where side slopes were 50% or greater. Draws and stream beds were to be cleaned 15.5 m upstream from culvert inlets, and road cuts and fills were to be grass seeded upon completion. The roads were completed as of August 1993.

To evaluate the BMPs for road construction, channel condition surveys were conducted prior to the road being built. Our surveys were around the P-line for the new road construction. The study reaches encompassed the proposed road crossings. In addition, a channel condition survey was conducted on a control study reach located approximately 2 km to the east, on a similar stream. After road construction was completed, photo point network surveys were conducted on the treatment reaches above and below the road crossings. Future surveys planned include cutbank/fillslope and culvert condition surveys, as well as follow-up surveys to those already conducted.

Site W-04: 1600 Mainline

The site is near Hemlock Pass, approximately 4 km east-southeast of our Train Whistle study site, in the north central area of Cowlitz County in the Willapa Hills physiographic region. Active haul-road maintenance is being evaluated at this site. The underlying geology is a basaltic-andesite lava flow member of the Goble volcanics of upper Eocene age. The soils consist of Olympic silt loam, tuff substratum, 5-30% slopes. Disturbed soil stability is rated as stable with cutbank/fill/sidecast and erosion potential hazards rated as moderate and medium, respectively. The stream valley side slope hazard category is moderate. A 1st order, Type 4 tributary to Mulholland Creek is crossed by the mainline haul-road at our study site. Mulholland creek is a tributary to the Coweeman River which flows into the Columbia River at the town of Longview.

The BMPs to be evaluated are the active haul-road practice activities. Maintenance schedules vary according to traffic volume, weather conditions, and road-surface integrity. During preliminary field reconnaissance surveys ditch cleaning was observedfor a ditch draining into the Type 4 stream. It is anticipated that maintenance activities will occur periodically throughout the duration of the project.

To date, field reconnaissance and channel condition surveys have been conducted. Future planned surveys for winter and spring of 1994 and 1995 will include runoff sampling and road surface condition surveys.

Site W-05: Bus Stop

This site is located in northeastern Clark County in the Willapa Hills physiographic region. The site is being evaluated for road construction, and harvest practices may also be evaluated depending on timing of harvest and project workload constraints. The underlying geology of the site is lower Miocene basalt-andesite and andesite lava flows. Soils consist of Newaukum cobbly silt loam, 5-30% slopes for the new road construction with the stream lying predominantly in Cinebar silt loam, 3-8 % slopes. Both soils share identical soil hazard ratings with disturbed soil stability rated as stable, and cutbank/fill/sidecast and erosion potential rated as moderate and medium, respectively. The slope hazard category for both the road construction area and the harvest unit is moderate. The road crosses the head of a zero order Type 5 tributary to Big Tree Creek which is a tributary to the Lewis River. Below the road the stream's channel morphology is classified as step-pool, formed by woody debris.

Forest practices at the site include 1.2 km of new road construction. The entire length of new road construction is within the boundaries of a planned 32 ha clearcut. The unit is rectangular in shape with the road traversing the long side of the rectangle in the northern section. The Type 5 channel begins just below the road and flows through the proposed harvest area. The road was completed in the summer of 1993. Harvest is proposed for summer of 1994.

BMPs selected for evaluation include the new road construction across and in the vicinity of the Type 5 stream. Surveys of the road included a culvert condition survey and photo point network survey. The purpose of the photo point network survey is to monitor the condition of the channel head immediately below the road. A channel condition survey was conducted on the stream below the new road on the Type 5 stream. Future surveys will include follow-up surveys to those already conducted and cutslope/fillslope surveys.

Site W-06: Pot Pourri

The Pot Pourri site is located in western Thurston County within the Capitol State Forest in the Willapa Hills physiographic region. Harvesting practices which include an RMZ will be evaluated for this site. The Pot Pourri site is a part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife RMZ transects. The underlying geology is middle Eocene volcanic rocks of submarine basalt flows and flow breccia. Soils consist primarily of Boistfort silt loam, 2040% slopes. The disturbed soil slope stability rating is stable, with soil hazard ratings for cutbank/fill/sidecast road construction and erosion potential of moderate and medium, respectively. The harvest slope hazard category is high. The site contains a 3rd order Type 3 stream (Porter Creek) which is a tributary to the Chehalis River. Porter's Creek channel morphology is classified as pool-riffle. Active channel width, is 6 m with an average channel gradient of 1%

Forest practices include a 33 ha harvest with 1.9 km of road construction of which about 0.5 km are within the harvest unit. The harvest covers both sides of Porter Creek with an accompanying RMZ. The harvest was conducted using cable-yarding and was completed in February 1994.

The BMP selected for evaluation is the RMZ within the cable harvest unit. Two study reaches have been established on Porter creek. The treatment reach is within the RMZ while the control is upstream of the harvest unit boundary. To date both reaches have been evaluated using channel condition surveys and photo point networks. Stream amphibian surveys were conducted within the treatment reach as part of the CMER Wildlife-RMZ research project. Future surveys planned for the site include sediment routing surveys, as well as follow-up surveys to those already conducted,

Site W-07: Night Dancer

The Night Dancer site is a harvest practice located southeast Grays Harbor County in the Capitol State Forest in the Willapa Hills physiographic region. This site is part of the CMER Wildlife-RMZ research project with our surveys being co-located with their RMZ transect. The underlying geology consists of middle Eocene volcanic and intrusive rocks of submarine basalt flows and flow breccia. Soils are primarily Raught silt loam, 30-65 % slopes for the stream and most of the harvest unit, with some soils in the eastern half of the harvest unit being Boisfort silt loam, 8-30 % slopes. Both soils share a disturbed slope stability rating of stable, and cutbank/fill/sidecast and erosion potential hazard ratings of moderate and medium, respectively. The harvest BMP hazard category is high with side slopes ranging from 29% to 46%. The study stream is a 1st order tributary to Porter Creek which flows into the Chehalis River near the town of Porter. This stream segment is depicted as a Type 5 on the official DNR Water Type map, however it appears to meet the physical criteria for a Type 4 or possibly a Type 3, and is being treated with a standard regulation RMZ for the purpose of the wildlife-RMZ study. The stream's channel morphology is step-pool. Active channel width is 2.5 m with an average gradient of 10%.

The proposed harvest is a 38 ha clearcut with 2.4 km of new road construction, of which about 2.2 km are within the harvest unit. The harvest unit is bisected by the stream with no road access across the stream within the unit. An RMZ has been proposed for both sides of the unit. To date no harvest activities have occurred on site and none are anticipated until late 1994.

The BMP selected for evaluation is the RMZ along the stream. A study reach has been established on the stream and a control reach has been established outside of the unit on a different Type 4 stream located about 1 km to the northeast along the same ridge line. The control reach is also a tributary to Porter Creek. To date channel condition and photo point network surveys have been conducted on both study reaches. The treatment reach has received a stream amphibian surveys as part of the Wildlife-RMZ project. Future surveys planned include sediment routing surveys to be conducted after the harvest has taken place. However, there is a chance that this site will be dropped from our study if the harvest is not completed by the end of 1994.

Southern Cascades Physiographic Region

Site S-01: Camp One Road

The Camp One Road site is located in south-central Pierce County in the Southern Cascades physiographic region. Active haul-road maintenance is being evaluated at this site. The surface geology of the site is classified as unconsolidated glacial drift. Soils at the study site are mapped as fluvaquents and humaquets, O-3 % slopes. These soils are rated as stable for disturbed slopes, a cutslope/fill/sidecast hazard was not assigned, and their erosion potential is low. Valley side slopes estimated along the study reach place the site within the low slope hazard category. The study stream on this unit is a 2nd order, type 3 stream named Ohop Creek. Ohop Creek is a tributary to the Nisqually river. Both the control and treatment reaches have pool-riffle morphologies and average stream gradients of 2-3 %

The forest practice BMP being evaluated at this site is active haul road maintenance. The road at the stream crossing is crowned and surfaced; where present, cutslopes and ditches are well vegetated. Maintenance schedules vary according to traffic volume, weather conditions, and road-bed integrity. Maintenance activities consist primarily of application of crushed rock and grading. Ditch clean-out in the vicinity of our study site does not appear to occur on a regular basis--grasses and shrubs are well established to the edge of the running road surface. It is anticipated that maintenance activities will occur periodically for the duration of the project.

Ohop Creek drains beneath the mainline road via two large culverts placed parallel to each other. Two study reaches have been established on the creek. The control reach is located upstream of the road crossing, with the treatment reach located immediately downstream of the crossing. Channel condition surveys have been conducted on both reaches. Runoff sampling and road surface condition surveys have also been conducted at the site. Additional runoff sampling and road surface condition surveys are planned for winter and spring seasons of 1994 and 1995.

Site S-02: 8 Road Unit 2

The 8 Road Unit 2 site is located in south-central Pierce County in the Southern Cascades physiographic region. New road construction BMPs are being evaluated at this site. The surface geology of the area is classified as Eocene/Oligocene aged basalt and andesite flows. Soils at the site are mapped as Jonas gravelly silt loam, 30-65% slopes. The soils are rated as stable for disturbed slopes, with a moderate hazard rating for cutslope/fill/sidecast construction, and a medium erosion potential. Based on slope estimates at the stream crossings, the slope hazard category for the site is moderate for new road construction BMPs. The newly constructed road crosses two drainages: a 1st order Type 4 and a zero order Type 5. The study streams are located on the access road leading into the 8 Road Unit 2 harvest area, not within the unit boundary area. Both streams are sub-drainages of Neisson Creek, a tributary to the Puyallup River.

Forest practices being evaluated at this site are new road construction BMPs. Approximately 2.2 kilometers of new road was constructed. The culverted road crossings, drainage design, and construction techniques are being evaluated. Construction of the segment of road we are evaluating was completed during the summer of 1992 using sidecast construction techniques.

A cutslope/fillslope survey has been conducted which encompassed both stream crossings. A culvert condition survey was conducted for almost the entire length of road. Follow-up surveys are planned for the 1994 and 1995 field seasons.

Site S-03: Ohop Blowdown

The Ohop Blowdown site is located in south-central Pierce County in the Southern Cascades physiographic region. Forest practices being evaluated at the site are new road construction BMPs. The surface geology of the site is classified as Eocene/Oligocene-aged basalt and andesite flows. Soils at the site have been mapped as Jonas gravelly silt loam, 30-65 % slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard, and a medium erosion potential. Based on sideslope gradients within the stream valleys the site has a high slope hazard category rating for new road construction. The study stream crossed by the new road construction is a type 5, zero order tributary to Twenty-five Mile Creek. Twenty-five Mile creek is a sub-drainage of Ohop Creek, a tributary to the Nisqually River.

Forest practices being evaluated at this site are new road construction (BMPs) using balanced cut and fill and sidecast construction techniques. The Type 5 stream crossed by the new road was passed using a culvert. Approximately 1.8 kilometers of new road were constructed The road construction was completed by September of 1992.

Culvert condition and cutslope/fillslope surveys have been conducted to evaluate new road construction BMP effectiveness at the site. Future surveys include follow-up surveys to those already conducted, as well as further reconnaissance of the Type 5 stream for determining channel morphology and average channel gradient. Additional surveys are planned for 1994 and 1995.

Site S-04: Friday Creek II

The Friday Creek II unit is located in southeast King County in the Southern Cascades physiographic region. Harvesting activities are being evaluated at this site. An RMZ established along the Type 3 stream is being monitored for BMP effectiveness. High lead (cable yarding) systems were used to transport trees cut within the unit. Yarding across the stream and through the RMZ occurred in two places. The surface geology of the area is classified as Eocene/Oligocene-aged andesites, basalt breccias, and tuff. Soils at the study site are mapped as Pitcher sandy loam and exposed breccia substratum, 30-65 % slopes. These soils are rated as unstable for disturbed slope stability, with a severe cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slope measurements taken within the study reach, the site has a high hazard rating for harvest, (side slopes range from 44-48 % adjacent to the stream). The study stream is a 2nd order, Type 3 stream that is an unnamed tributary to the Green River. The treatment reach within the unit has a step-pool/cascade morphology, and an average channel gradient of 14%.

The forest practice being evaluated at this site is the Riparian Management Zone (RMZ). The harvest unit is a 23 hectare clearcut with 100% volume removal outside of the RMZ. Trees cut on the west side of the creek, (approximately 0.5-l hectares), were yarded to the east side using cable systems. Two "roads" through the RMZ were established for yarding. The harvesting was completed in March of 1993.

Two study reaches, a treatment and a control, were established on the Type 3 stream buffered by the RMZ. The control reach is located upstream of the unit boundary. This reach has a cascade morphology, and an average channel gradient of 15 % . Stream reconnaissance and channel condition surveys were conducted at both reaches. A sediment routing survey was conducted along the treatment reach. Stream amphibian surveys are being conducted by University of Washington researchers within the treatment reach. Future efforts will include follow-up surveys to those previously described. Surveys will be conducted during the 1994 and 1995 field seasons.

Sundog05:

The Sundog site is located in north-central Pierce County in the Southern Cascades physiographic region. Harvesting practices are being evaluated at this site. The surface geology of the site is classified as alpine glacial deposits and ancient mudflows (the Ohanopecosh Formation). Soils at the site are mapped as Larrupin gravelly sandy loam, 30-65 % slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard and a medium erosion potential. Based on side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvest BMPs (side slopes range from 36-70% adjacent to streams). Our study stream at Sundog is a 1st order, Type 5 stream which was buffered with a Riparian Leave Tree Area (RLTA). The stream is a tributary to the Carbon River. The average stream gradient is 28%.

The forest practice being evaluated at the site is the RLTA buffering the Type 5 stream. The harvest unit is a new forestry partial cut with a total size of 46.5 hectares. Approximately 50 % of the total area was yarded with cable systems; the remaining area was shovel logged. Total volume removal of trees was estimated at 85 percent. We are evaluating the effectiveness of the RLTA in preventing sediment delivery to the Type 5 stream, adjacent to which the trees were yarded using a cable system. The harvesting was completed in June of 1993.

A sediment routing survey was conducted on the buffered Type 5 from the upper road to the lower road. This Type 5 is the most westerly drainage in the unit with an RLTA. Stream amphibian surveys are being conducted on this stream between the two roads by researchers from the University of Washington. Follow-up sediment routing surveys are scheduled for the 1994 and 1995 field seasons.

Site S-06: Big Wedge

The Big Wedge site is located in north-central Lewis County in the Southern Cascades physiographic region. Harvesting practices are being evaluated at this site. The surface geology of the site is classified as basaltic andesite and andesite flows. Soils at the study site are mapped as Pheeney-Jonas complex, 8-30% slopes. The soils are rated as stable for disturbed slope stability, with a slight cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvesting BMPs (side slopes range from 19-55 % adjacent to streams). Our study stream in this unit is a 1st order, Type 4 drainage that is a tributary to Mineral Creek. Mineral Creek is a tributary to the Nisqually River. Two treatment reaches have been established within the unit. Each treatment reach has step-pool morphology, and an average channel gradient of 9 % .

Forest practices being evaluated at this site are ground-based harvesting adjacent to a Type 4 stream buffered with a Riparian Leave Tree Area (RLTA). The harvest unit applied for is a 15 hectare clearcut. As of early May 1994, the unit had not yet been cut.

Three study reaches have been established on the Type 4 stream which is buffered by the RLTA. Channel condition surveys and photo point networks were established on both treatment reaches and the control reach. The upper treatment reach and the control reach were surveyed for streambed stability. The control reach for the site is located on the same Type 4, upstream from the unit boundary.

Site S-07: eleven Creek 32

The Eleven Creek 32 site is located in north-central Lewis County in the Southern Cascades physiographic region. Harvesting BMPs evaluated at this site include a Riparian Management Zone (RMZ), Tractor and Wheeled Skidding, and, secondarily, cable yarding. The site is part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife RMZ transects. The surface geology of the area is classified as Eocene-aged basalt and andesite flows. Soils at the study site are mapped as Baumgard loam, 8-65 % slopes. These soils are rated as stable for disturbed slope stability, with a slight to moderate cutslope/fill/sidecast hazard, and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvesting BMPs. Our study stream on this unit is a 1st order stream, the upper reaches of which are classified as Type 5 according to the DNR Water Type map and the FPA. However, the stream appears to meet the physical criteria (e.g. channel width) for a Type 4 upstream of where the Water Type change is indicated on the official maps. The study stream is a tributary to Eleven Creek, which is a sub-drainage of the Skookumchuck River. Two treatment reaches have been established on the study stream. The first treatment reach has a cascade morphology with an average stream gradient of 26%. The second treatment reach has a step-pool morphology with an average stream gradient of 15 %

Forest practices being evaluated at the site include a Riparian Management Zone (RMZ) and the ground-based (shovel) and cable harvesting practices adjacent to the study stream. The uppermost segment of the stream is not buffered. The downstream portion of the stream is being buffered with a Type 3 regulation RMZ for the purposes of the Wildlife-RMZ study. The harvest unit is a 41 hectare clearcut. Harvesting is expected to be completed in May of 1994.

Channel condition surveys and photo point surveys have been conducted on the two study reaches (one above and one within the RMZ). The control reaches for the site are located at another Wildlife-RMZ study site referred to as Vail Control. In addition to the surveys we have conducted, the wildlife researchers have conducted stream amphibian surveys within our downstream treatment reach and at Vail Control.

Site S-08: Kapowsin

The Kapowsin site is located in southeast Pierce County in the southern Cascades physiographic region. Harvesting practices are being evaluated at this site. The Kapowsin site is part of the CMER Wildlife-BMZ research project, and we have surveys co-located with the wildlife RMZ transects. The surface geology of the site is classified as Eocene-aged basalt and andesite flows as well as Mount Rainier mudflows. Soils at the study site are mapped as Wilkeson gravelly silt loams, 30-65 % slopes, and Klaber-Cmebar complex, O-3 % slopes. The Wilkeson loam is rated as stable for disturbed slope stability, with a slight cutslope/fill/sidecast hazard and a medium erosion potential. The Klaber-Cmebar complex is rated as stable for disturbed slope stability, the cutslope/fill/sidecast hazard is not applicable, and the erosion potential is low. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvest BMPs (side slopes range from 29-130% adjacent to the stream). Our study stream at this site is a 2nd order, Type 3 tributary to Twenty-Five Mile Creek. The treatment reach has a step-pool morphology with an average channel gradient of 11% , and runs through a steep inner gorge in sections.

Forest practices being evaluated at this site include ground-based (shovel and tractor or wheeled skidding) and cable harvesting as well as a regulation RMZ along the Type 3 stream. The harvest unit is a 46 hectare clearcut. The harvest has been delayed, and is now scheduled to be completed no later than March 1995.

A study reach has been established on the Type 3 stream buffered by the RMZ. Channel condition surveys, photo point surveys, and streambank erosion surveys have been conducted at the reach. Stream amphibian surveys are being conducted within the study reach by personnel from the Wildlife-BMZ research project. The control reach for this site is located at another Wildlife-RMZ study site referred to as Elbe Control. A sediment routing survey will be conducted along the RMZ following the harvest as will follow-up photo point, channel condition, streambank erosion, and amphibian surveys.

Site S-09: Simmons Creek

The Simmons Creek site is located in south-central Lewis County in the Southern Cascades physiographic region. Harvesting practices are being evaluated at this site. The Simmons Creek site is a part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife-RMZ transects. The surface geology of the area is classified as Eocene/Oligocene-aged andesite and basalt flows. Soils at the site are mapped as Newaukum gravelly silt loam, 1530% and 30-65% slopes. These soils are rated as stable for disturbed slope stability, with a slight to moderate cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category rating for harvesting BMPs (side slopes range from 25-45% adjacent the study streams). Our study streams on this unit include Simmons Creek, a 1st order, Type 3 stream, and a Type 5, zero order tributary to Simmons Creek. Simmons Creek is a tributary to the Cowlitz River. The study reach on Simmons Creek has a step-pool morphology with an average channel gradient of 8% The study reach on the Type 5 stream has a step-pool morphology with an average channel gradient of 11% .

Forest practices being evaluated at this site include ground-based harvesting (shovels and/or tracked or wheeled skidders) and a regulation RMZ. Secondary information on cable yarding practices may also be evaluated. The harvest unit is a 49 hectare clearcut. The harvest was completed in March of 1994.

A study reach has been established along Simmons Creek that is buffered by the regulation RMZ. Surveys along this study reach which have been conducted include channel condition, photo point network, streambank erosion, and macroinvertebrate and stream amphibian sampling. The macroinvertebrate sampling was conducted by staff from Ecology's Ambient Monitoring Section. Members of the CMER Wildlife-RMZ research project conducted the stream amphibian surveys. A channel condition survey, photo point network, and macroinvertebrate survey were conducted on the Type 5 study reach. The control reaches for Simmons Creek and the Type 5 are located at the Elbe Control Wildlife-RMZ study site. In addition to follow-up surveys on those already conducted, a sediment routing survey is planned following the harvest.

Northern Cascades Physiographic Region

Site 01: Upper Shoo

The Upper Shop site is a new road construction and harvest site with RLTAs located in southwest Skagit County in the Northern Cascades physiographic region. The underlying geology consists of early Cretaceous metamorphic rocks. The northern one-quarter of the unit is Shuksan greenschist, a predominantly fme-grained greenschist with the lower three-quarters of the unit consisting of Danington phyllite. Soils consist of Sorenson very gravelly silt loam, 3-30% slopes. Slope stability for disturbed slopes is stable with a moderate hazard for cutbank/fill/sidecast and a low erosion potential hazard. The slope hazard category for both the harvest and road construction is moderate. There are eight zero order streams within the unit. Two of them are Type 5 streams that originate within the unit and flow into a Type 4. This Type 4 stream originates upstream of the unit as a Type 5 and flows a short distance across the unit before exiting, and re-entering the unit as a Type 4. There are three other Type 4 streams in the unit, tow of which have Type 5 tributaries. All of these streams flow into Pilchuck Creek which flows into the Stillaguamish River just east of the town of Silvana. We selected one of the Type 4 streams which is crossed by the upper road for study. Its' average channel gradient is 10 %. Additional stream reaches may be assessed for harvest practices.

The forest practice is a 46 hectare clearcut with 1.8 kilometers of new road construction. The four Type 4 streams have RLTAs with harvest being conducted by ground-based equipment (including shovels). The Type 5 streams were not buffered. The road construction was completed between December 1992 and March 1993, with the harvest completed by April of 1993.

The BMPs selected for evaluation include new road construction, ground-based harvesting around the Type 4 stream, and the RLTA along the Type 4 stream. Two study reaches, treatment and control, were established on the Type 4 stream. The control reach is upstream of the treatment reach and the road, within the upper portion of the harvest unit. This reach serves primarily as the control for evaluating road effects. A suitable off-site control reach for evaluation of harvest practices was not found, due to the differences in stream character upstream of the unit. In July of 1993 channel condition surveys and photo point network surveys were conducted on both the treatment and control reaches. At the same time road surveys were conducted, including culvert condition and cutbank/fillslope surveys. Future surveys include sediment routing surveys for evaluation of the harvest practices, as well as follow-up surveys to those already conducted.

Site N-02: Pilchuck Mainline

The Pilchuck Mainline site is located in south-central Skagit County in the Northern Cascades physiographic region. Active haul road maintenance is being evaluated at this site. The surface geology of the site is classified as glacial recessional outwash deposits of the Vashon stage consisting primarily of stratified sands and gravels. Soils at the study site are mapped as Saxon silt loams, 0-30% slopes. These soils are rated as stable for disturbed slopes with a moderate cutslope/fill/sidecast hazard and a low erosion potential. The BMP slope hazard category for the site is moderate. The study stream is a 2nd order, Type 3 tributary to Pilchuck Creek. Pilchuck Creek is a sub-drainage of the Stillaguamish River. A treatment reach was established below the mainline road crossing with a stream morphology of step-pool/pool-riffle and an average stream gradient of 3%. The control reach established on the same stream above the road crossing has a pool-riffle morphology and an average stream gradient of 2 %.

The forest practice BMP being evaluated at this site is active haul road maintenance. The road at the stream crossing is crowned, bermed, and ditched; where present, cutslopes and ditches are well vegetated. Maintenance schedules vary according to traffic volume, weather conditions, and road-bed integrity. Maintenance activities consist primarily of grading. Ditch clean-out in the vicinity of our study site does not appear to occur on a regular basis--grasses and shrubs are well established to the edge of the running road surface. It is anticipated that maintenance activities will occur periodically for the duration of the project.

The study stream drains beneath the road via a 1.8 m diameter culvert. The surveys completed to date include field reconnaissance, channel condition, runoff sampling, and road surface condition. Follow up surveys for those already conducted are planned for the 1994 and 1995 field seasons.

Eastern Cascades Physiographic Region

Site E-01: Fish Lake Mine

The Fish Lake Mine site is located in extreme north-central Kittitas County in the Eastern Cascades physiographic region. Both harvesting and new road construction practices are being evaluated at the site. The surface geology of the site is classified as part of the Ingalls tectonic complex, an ancient ocean fault zone consisting of metamorphosed rocks-- primarily serpentine. Soils at the study site are mapped as Waptus very stony sandy loams, 45-65 % slopes. The soils are rated as very unstable for disturbed slope stability, with a severe cutslope/fill/sidecast hazard and a high erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for both harvesting and new road construction BMPs (side slopes range from 11-53% adjacent to streams). Our study stream on this unit is a zero order, Type 5 tributary to Silver Creek, a tributary to the Cle Elum River. Two study reaches established on the Type 5 stream have step-pool morphologies, with average channel gradients of 12 and 17 %.

Forest practices being evaluated at the site include ground-based (tractor and wheeled skidding) and cable yarding practices as well as new road construction. The harvest unit is a 24 hectare partial cut with 75 % volume removal. 2.4 kilometers of new road were constructed to access the unit. A temporary log and culvert crossing of the Type 5 stream is being evaluated. Road construction was completed by the end of August 1992. The harvest was completed in September 1993.

Two study reaches have been established on the Type 5 stream, one is upstream of the temporary crossing, the other downstream. Initially, we did not anticipate that the harvest area would include the study reaches, which were intended to evaluate the road crossing. Since the harvest did encompass both reaches, we will use a "before and after" approach to evaluate harvest effects on these reaches. We do not have an off-site control stream for this site, but we may use the control reach from site E-02 for comparison. Channel condition surveys and photo point networks have been conducted on both reaches. A sediment routing survey was conducted in the vicinity of the Type 5 stream following the harvest. A cutslope/fillslope survey was conducted along the portion of the road draining to the Type 5 stream.

Site E-02: Plesha Road

The Plesha Road site is located in west-central Kittitas County in the Eastern Cascades physiographic region. New road construction practices are being evaluated at this site. The surface geology of the site is classified as alpine glacial deposits, primarily sand and gravel outwash. Soils at the study site are mapped as Nard loam and Nard silt loam, 25-45% slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the moderate slope hazard category for new road construction BMPs, (side slopes range from 12-46% adjacent to the road crossing of the stream). Our primary study stream on this unit is a zero-order, Type 4 stream that is a tributary to Cle Elum Lake on the Cle Elum river. The study reach on this stream has a step-pool morphology with an average gradient of 15 % .

Forest practices 'being evaluated at this site are new road construction BMPs. 1.1 kilometers of new road was constructed to access approximately 15 hectares of forest that was partially cut (75% volume removal). Cutting did not occur in the vicinity of our study stream. A culverted road crossing of the Type 4 stream is being evaluated as is road construction in the vicinity of a Type 5 stream. The road construction was completed in June of 1992.

A treatment reach has been established on the Type 4 downstream of the culverted road crossing. Photo point networks, channel condition surveys, and a streambank erosion survey have been conducted at the study reach. A control reach is located upstream of the road on the same Type 4 stream. Cutslope/fillslope and culvert condition surveys have been conducted on the road leading to the crossing of the Type 4. The cutslope/fillslope survey was conducted within the road drainage area leading to the Type 4 crossing. The culvert condition survey encompassed nearly the entire road.

Site E-04: Green Canvon

The Green Canyon site is located in northeast Kittitas County in the Eastern Cascades physiographic region. Harvesting practices, (tractor and wheeled skidding), are being evaluated at this site. The surface geology of the area is classified as the margin of the Columbia plateau basalt flows. Soils at the site are varied, the most common soil type is Loneridge stony loam, 25-45 % slopes. These soils are rated as stable for disturbed slope stability with a moderate cutslope/fill/sidecast hazard, and medium erosion potential. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvesting BMPs (side slopes range from 18-66% adjacent to streams). Study streams within this unit include a 1st order, Type 3 stream and two zero-order Type 5s. 'The Type 5 streams are tributaries to the Type 3 stream. The Type 3 is a sub-drainage of the Yakima river.

The forest practices being evaluated at this site are tractor and wheeled skidding and a RMZ along the Type 3 stream. The harvest unit is a 162 hectare partial cut. The tree cutting was completed by November 1992.

Photo point surveys have been conducted along one of the Type 5 streams and on three skid trails. Sediment routing surveys have been conducted on one of the Type 5s and along a portion of the Type 3 stream with the RMZ.

Site E-05: The Aspen Patch

The Aspen Patch site is located in north-central Kittitas County in the Eastern Cascades physiographic region. Harvesting practices including tractor and wheeled skidding and an RMZ are being evaluated at this site. The surface geology of the area is classified as alluvium consisting of sand and gravel deposits. Soils at the study site are mapped as Nard loam and Nard silt loam, 0-25% slopes. These soils are rated as stable for disturbed slope stability, with a slight cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study area the site falls into the low hazard category for harvesting BMPs (side slopes range from 0-2% adjacent to the stream). Our study stream on this unit is a 2nd order, Type 4 that is a tributary to the west fork of the Teanaway River.

The forest practices being evaluated at this site are tractor and wheeled skidding and an RMZ along the Type 4 stream. The unit is a 65 hectare partial cut with 60% volume removal. 0.8 kilometers of road was constructed to access the cut area with another 0.2 kilometers of road reconstruction. The cutting was completed by the end of September 1992.

A sediment routing survey was conducted along the entire length of the RMZ in order to evaluate harvesting BMP effectiveness.

Northern Rockies Physiographic Region

Site R-01: Cee Cee Ah

The Cee Cee Ah site is located in central Pend Orielle County in the Northern Rockies physiographic region. Both harvesting and road construction practices may be evaluated at this site. While the timber has been sold, harvesting has not yet begun at this site, although road construction work has been completed. It is possible that this site may be dropped from the study if timber harvesting does not proceed soon. A decision will be made during the summer of 1994 on whether to keep the site as part of the study. The surface geology of the area is a mixture of glacial outwash and till deposits, the Tiger Formation (an Eocene-aged conglomerate), and Precambrian metamorphic rocks of the Belt Supergroup. Soils in the vicinity of our prospective study sites are mapped as Inkler-Rock outcrop complex, 20-40 % slopes; Inkler gravelly silt loam, 40-65 % slopes; and Newbell silt loam, 0-25 % slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard and a medium to high erosion potential. The BMP slope hazard category will be determined when specific stream reaches are selected for evaluation. The proposed harvest area includes several zero order Type 5 streams and one 2nd order, Type 3 stream (Cee Cee Ah Creek), which are in the Pend Orielle River drainage.

Forest practices which may be evaluated at this site include ground-based harvest practices (tractor and wheeled skidding), an RMZ along Cee Cee Ah Creek, and road construction/reconstruction practices. Harvest plans include about 78 ha of clearcut harvest and about 143 ha of partial cut harvest with 55 % volume removal, The FPA indicates approximately 9 km of road construction and reconstruction within the unit.

If the harvest proceeds in a timely manner, we anticipate establishing study reaches along Cee Cee Ah Creek to evaluate the effectiveness of the RMZ. Qualitative channel condition and photo-point surveys would be used in conjunction with sediment routing surveys. If road construction in the vicinity of streams is evaluated, we will conduct cutbank/fillslope surveys and culvert condition surveys during the summer of 1994 and 1995. We also anticipate conducting sediment routing surveys to evaluate harvesting practices in the vicinity of Type 5 streams.

Site R-02: Muddy West

The Muddy West site is located in northwestern Pend Orielle County in the Northern Rockies physiographic region. Both harvesting and road construction practices are being evaluated at this site. The Muddy West site is a part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife RMZ transects. The surface geology of the area is classified as glacial drift deposits. Soils of the study site are mapped as Aits loam (high precipitation), 15-25 % slopes. These soils are rated as stable for disturbed slope stability, with a slight cutslope/fill/sidecast hazard and a medium erosion potential Based on valley side slopes measured in the vicinity of our study reaches, the site falls into the high slope hazard category for harvest BMPs and the moderate category for road BMPs (side slopes range from 21 to 49% adjacent to streams). Our study streams on this unit include a 1st order, Type 4 stream that is a tributary to Big Muddy Creek (which enters the Pend Orielle River at the town of Ione), and a zero order, Type 5 stream that is a tributary to the Type 4. Both study streams have step-pool channel morphologies, with average channel gradients of 10% and 12%, respectively for two study reaches on the Type 4 stream, and an average channel gradient of 14% within our study reach on the Type 5.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding), an RMZ (the Type 4 stream is being treated with a Type 3 regulation RMZ for the purposes of the Wildlife-RMZ study), and new road construction/reconstruction practices. The harvest unit is a 37 ha partial cut with 40% volume removal. There are approximately 3.2 km of road construction, of which about 0.8 km involve reconstruction along an overgrown route. Two culverted road crossings of the Type 4 stream are under evaluation. The road construction into the harvest unit was completed in October of 1993. The timber harvest was completed in January of 1994.

Two study reaches have been established on the Type 4 stream which is buffered by the RMZ. Channel condition surveys and photo-point surveys have been conducted at both of these reaches, and a streambank erosion survey has been conducted at one of the reaches. The control reach for the Type 4 stream is located in an adjacent drainage just to the north of the treatment area, within the "Muddy Control" site of the Wildlife-RMZ study. In addition to the surveys we have conducted, the wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach we are evaluating. An additional study reach has been established along the Type 5 tributary, which is contained within the harvest unit for the majority of its channelized length. This tributary is not buffered outside of the RMZ boundaries. Surveys conducted to date on the Type 5 study reach include a channel condition survey, photo-point survey, and streambed stability survey. The control reach for the Type 5 is located upstream of the Type 4 control reach at the "Muddy Control" site. In addition to the above-mentioned surveys to evaluate harvest practices at this site, we also plan to conduct sediment routing surveys along the RMZ and in the vicinity of the Type 5 stream. For evaluation of road construction practices, we have conducted two cutbank/fillslope surveys in the vicinity of the two primary stream crossings, and a culvert condition survey that covers most of the length of the road. In addition, two of the above-mentioned stream survey reaches are adjacent to and/or downstream of the reconstructed portion of the road.

Site R-03: Muddy East

The Muddy East site is located just to the northeast of the Muddy West site, in northwestern Pend Orielle County in the Northern Rockies physiographic region. Harvesting practices are being evaluated at this site. The Muddy East site is also a part of the CMER Wildlife-RMZ research project, and we have surveys located within the wildlife RMZ transects. The surface geology of the area is classified as glacial drift deposits. Soils of the study site are mapped as Aits loam (high precipitation), 15-25 % slopes, with the 25-40 % slope phase of Aits loam occurring in the northeast comer of the unit. The 15-25 % phase soils are rated as stable for disturbed slope stability, with a slight cutslope/fill/sidecast hazard and a medium erosion potential. The 25-40 % phase has similar soil management interpretations, except that it is rated as having a moderate cutslope/fill/sidecast hazard. Based on valley side slopes measured in the vicinity 'of our study reach, the site falls into the moderate slope hazard category for harvest BMPs (side slopes range from 14 to 33 % adjacent to the stream). Our study stream on this unit is a 1st order, Type 4 stream that is a tributary to Big Muddy Creek in the Pend Orielle River basin. The stream has a step-pool channel morphology, with an average channel gradient of 10% within our study reach.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding) and an RMZ (the Type 4 stream is being treated with a Type 3 regulation RMZ for the purposes of the Wildlife-RMZ study). The harvest unit is a 30 ha partial cut with 40% volume removal. Timber harvest was completed in January of 1994.

One study reach has been established on the Type 4 stream which is buffered by the RMZ. A channel condition survey, photo-point survey, and a streambank erosion survey have been conducted at this treatment reach. The control reach is located upstream of Muddy East within the "Muddy Control" site of the Wildlife-RMZ study (it is the same as the control reach for Muddy West). In addition, the wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach we are evaluating. We also plan to conduct sediment routing surveys along the RMZ.

Site R-04: Buck East

The Buck East site is located in the southwestern part of Pend Orielle County in the Northern Rockies physiographic region. Harvesting practices are being evaluated at this site. The Buck East site is part of the CMER Wildlife-RMZ research project. The surface geology of the area is classified as Phillips Lake Granodiorite, a medium to coarse-grained intrusive igneous rock of late Cretaceous age. Soils of the study site are primarily Moscow silt loam, O-25 % slopes, with the Skanid-Rock outcrop complex, 0-40% slopes, occurring on the ridgelines at the upstream end of the unit. Both soil mapping units are rated as stable for disturbed slope stability, with a moderate cutslopelfiisidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reach, the site falls into the moderate slope hazard category for harvest BMPs (side slopes range from 28 to 40% adjacent to the stream). Our study stream on this unit is a 1st order, Type 4 stream that is a tributary to Buck Creek which is a tributary to the West Branch of the Little Spokane River. The stream has step-pool channel morphology, with an average channel gradient of 10% within our study reach. There are also three zero order, Type 5 streams within the harvest unit.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding) and an RMZ (the Type 4 stream is being treated with an RMZ for the purposes of the Wildlife-RMZ study). The RMZ at Buck East was designed as an experimental treatment, meaning that it wilt provide enhanced riparian zone protection above the minimum requirements of a regulation RMZ. The harvest unit is a 49 ha partial cut with 50% volume removal. Timber harvest was completed in early March of 1994.

One study reach has been established on the Type 4 stream which is buffered by the RMZ. A channel condition survey has been conducted at this treatment reach. The control reach is located upstream of the harvest unit boundary on the same stream. The wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach. In addition to using channel condition surveys to evaluate harvest practices at this site, we also plan to conduct sediment routing surveys, along the RMZ and in the vicinity of the Type 5 waters.

Site R-05: Buck West

The Buck West site is located just to the west of the Buck East study site in southwestern Pend Orielle County in the Northern Rockies physiographic region. Ground-based harvesting practices are being evaluated at this site. The Buck West site is part of the CMER Wildlife-RMZ research project. The surface geology is mapped as Phillips Lake Granodiorite. Soils of the study site are Moscow silt loam in two phases, 40-65 % slopes and 0-25 % slopes, with the Mobate-Rock outcrop complex, 40-65 % slopes, and the Skanid-Rock outcrop complex, 0-40% slopes, occurring on the ridgelines. These soil mapping units are rated as unstable for disturbed slope stability, with a severe cutslope/fill/sidecast hazard and a high erosion potential on the 40-65 % slope phases. The O-25 % and O-40 % slope phases are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard and a medium erosion potential. Based on valley side slopes measured in the vicinity of our study reach, the site falls into the high slope hazard category for harvest BMPs (side slopes range from 10 to 44% adjacent to the stream). Our study stream on this unit is a 1st order, Type 4 stream that is a tributary to Buck Creek, which is a tributary to the West Branch of the Little Spokane River. The stream has step-pool channel morphology, with an average channel gradient of 7% within our study reach.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding) and an RMZ (the Type 4 stream is being treated with a Type 3 regulation RMZ for the purposes of the Wildlife-RMZ study). The harvest unit is a 29 ha partial cut with 60% volume removal. Timber harvest was completed in December of 1993.

One study reach has been established on the Type 4 stream which is buffered by the RMZ. A channel condition survey, photo-point network, and streambank erosion survey have been conducted at this treatment reach. The control reach is located upstream of the harvest unit boundary on the same stream. Wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach. In addition to the above-mentioned stream surveys, we also plan to conduct sediment routing surveys along the RMZ.

Site R-06: Middle

The Middle site is located in central Pend Orielle County in the Northern Rockies physiographic region. Harvesting practices are being evaluated at this site. The Middle site is part of the CMER Wildlife-RMZ research project. The surface geology of the area is a mixture of glaciolacustrine deposits, undifferentiated glacial drift deposits, and Mill Creek Granodiorite. Soils are primarily Inkler-Rock outcrop complex, 40-65% slopes; Scotia fme sandy loam, 15-25% slopes; and Sacheen loamy fine sand, 1525% slopes. The Inkler-Rock outcrop soils are rated as unstable for disturbed slopes stability, with the other soils on the unit rated as stable. All three soil mapping units are rated as moderate for cutslope/fill/sidecast hazard and medium for erosion potential. Based on valley side slopes measured in the vicinity of our study reach, the site falls into the high slope hazard category for harvest BMPs (side slopes range from 56 % to 65 % adjacent to the stream). Our study stream is a 2nd order, Type 3 stream named Middle Creek, which is a tributary to the Pend Orielle River. The stream has a cascade channel morphology, with an average channel gradient of 9 % within our study reach.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding) and a standard regulation RMZ. The harvest unit is a 61 ha partial cut with 70% volume removal. Timber harvest was completed in February of 1994.

One study reach has been established on Middle Creek which isbuffered by the RMZ. A channel condition survey has been conducted at this treatment reach. A suitable site-specific control reach was not located for this survey because the character of the channel was quite different above the unit. However, we may be able to use other control streams in the Northern Rockies region for general comparison purposes. We also plan to conduct sediment routing surveys along the RMZ at this site. In addition, the wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach.

Site R-07: Sherry Creek

The Sherry Creek site is located in eastern Stevens County in the Northern Rockies physiographic region. Both harvesting and road construction practices are being evaluated at this site. The Sherry Creek site is a part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife RMZ transects. The surface geology of the area is a mixture of glacial drift deposits and an undivided two-mica granitic rock. The predominant soils of the study site are Newbell silt loam, 40-65 % slopes; Bonner silt loam, 0-10 % slopes; Merkel-Rock outcrop complex, 40-65 % slopes; and Newbell stoney silt loam, O-40 % slopes. These soil mapping units are rated as unstable for disturbed slope stability, with a severe cutslope/fill/sidecast hazard and a medium to high erosion potential on the 40-65 % slope phases. The 0-10 % and 0-40 % slope phases are rated as stable for disturbed slope stability, with slight to moderate cutslope/fill/sidecast hazards and low to medium erosion potentials. Based on valley side slopes measured in the vicinity of our study reaches, the site falls into both the moderate and high slope hazard categories for harvest BMPs and the moderate category for road BMPs. Our study streams on this unit include a 1st order, Type 4 stream and a 1st order Type 5 stream, both of which are tributaries to Sherry Creek, as well as Sherry Creek itself (2nd order, Type 3/4). Sherry Creek is a tributary to the Little Pend Orielle River. These streams have step-pool channel morphologies, with average channel gradients ranging from about 4% to 6%.

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding), an RMZ (Sherry Creek is being treated with a Type 3 regulation RMZ for the purposes of the Wildlife-RMZ study), and road construction/reconstruction practices. The harvest unit is a 42 ha partial cut with 40% volume removal. There are approximately 2.1 km of road construction, of which a portion involved reconstruction along an existing route. Road crossings of the Type 4 stream and Sherry Creek are under evaluation. The road construction into the harvest unit was completed in September of 1993. The timber harvest was completed in January of 1994.

Two treatment reaches have been established on the Type 4 stream within the harvest unit, one above and one below the road crossing. Channel condition surveys, photo-point surveys, and streambank erosion surveys have been conducted at both of these reaches. The control reach for the Type 4 stream is located on the same stream upstream of the harvest unit boundary. Channel condition surveys and photo-point networks have been established on two treatment reaches and one control reach (upstream of the harvest boundary) on Sherry Creek. In addition to the surveys we have conducted, the wildlife researchers from Eastern Washington University are conducting riparian amphibii surveys along the RMZ reach we are evaluating. Additional study reaches have been established along the Type 5 tributary, which is not buffered outside of the RMZ boundaries, with photo-point networks established above and below a proposed road crossing. We also plan to conduct sediment routing surveys along the RMZ and in the vicinity of the Sherry Creek tributaries. For evaluation of road construction practices, we have conducted two cutbank/fillslope surveys in the vicinity of the two primary stream crossings, and a culvert condition survey that covers most of the length of the road. In addition, two of the above-mentioned stream survey reaches are located downstream of road crossings.

Site R-08: Amazon

The Amazon site is located in eastern Stevens County in the Northern Rockies physiographic region. Timber harvesting practices are being evaluated at this site. The Amazon site is a part of the CMER Wildlife-RMZ research project, and we have surveys which are co-located with the wildlife RMZ transects. The surface geology of the area is undifferentiated glacial drift deposits. The predominant soils of the study site are Nevine extremely bouldery loam, 30-65 % slopes; Kegel loam; Newbell stoney silt loam, 0-40 % slopes; and Newbell silt loam, O-25 % slopes. The Nevine soils are rated as unstable for disturbed slope stability, with a severe cutslope/fill/sidecast hazard and a high erosion potential. The other soils on the unit are rated as stable for disturbed slope stability, with a moderate cutslope/fill/sidecast hazard and low to medium erosion potentials. Based on valley side slopes measured in the vicinity of our study reach, the site falls into the low slope hazard category for harvest BMPs. Side slopes range from 5 to 10% along this stream in the upper portion of the unit. Our study stream on this unit is Amazon Creek, a 3rd order, Type 3 stream that is a tributary to the Little Pend Orielle River. This stream has a pool-riffle channel morphologies, with an average channel gradient of 1% .

Forest practices being evaluated at this site include ground-based harvest practices (tractor and wheeled skidding), and an RMZ. The harvest unit is a 43 ha partial cut with 40% volume removal. The timber harvest was completed in October of 1993.

Channel condition surveys and photo-point networks have been established on one treatment reach and one control reach (upstream of the harvest boundary) on Amazon Creek. Wildlife researchers from Eastern Washington University are conducting riparian amphibian surveys along the RMZ reach we are evaluating. In addition to the above-mentioned surveys to evaluate harvest practices at this site, we also plan to conduct sediment routing surveys along the RMZ at this site.