124

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WASHINGTON STATE DEPARTMENT OF ECOLOGY

TIMBER FISH & WILDLIFE

Appendices I and J

Effectiveness of Forest Road and Timber Harvest Best Management Practices with Respect to Sediment-Related Water Quality Impacts

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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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Submitted to:
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Appendix I

Field Survey Protocols

Appendix I: Field Survey Protocols

Field Reconnaissance Survey

Purpose:

The purpose of the field reconnaissance survey is: 1) to document information on a potential study site in order to apply objective criteria during study site selection; 2) to summarize logistics information for future work, including access, landowner contacts, etc.; 3) to apply a standardized methodology for classifying study sites into slope hazard categories; 4) to identify surveys which are appropriate and feasible for BMP evaluation and ascertain the availability of control streams; and 5) to collect site information for use in evaluating BMP effectiveness during follow-up surveys.

Materials:

Forest Practices Application (FPA)
area road map (*e.g.,* Gazetteer)
USGS 7.5 minute quadrangle maps
orthophoto maps of the relevant township or 1\4 township (if available)
aerial photos (1:12,000 scale)
soils maps and/or geology maps
DNR rain-on-snow zone maps
water type maps
clinometer
compass
wide angle, 35 mm. camera
100 meter measuring tape
field reconnaissance survey field forms
field book and lead pencils

Site Selection Criteria:

Following FPA review, candidate study sites are selected for the field reconnaissance survey. The primary criteria used to select sites for reconnaissance are: 1) the presence of type 1-5 waters in the vicinity of targeted forest practices; 2) timing (*e.g.,* whether it is possible to conduct preliminary road surveys after construction and before a significant hydrologic event); and 3) whether there is a good likelihood of isolating the site-specific effects of the BMP from the cumulative effects of concurrent or past land use activities such as forest practices, grazing, and mining.

Method Summary:

After initial office screening of Forest Practice Applications which appear to meet site selection criteria, field visits are made to potential study sites to ground truth the site selection criteria, and gather information on the site including logistics information, slope hazard class, and availability of control sites. Appropriate BMP effectiveness surveys are also identified during field reconnaissance.

Assumptions:

Study sites for targeted forest practices in targeted regions of the state are selected without bias, other than the need to meet site selection criteria.

Survey Methods:

1. Recently submitted FPAs for targeted BMPs in targeted regions of the state are obtained from DNR or Ecology regional offices or from landowner field offices. Following initial screening of FPAs for potential study sites, landowners are contacted, informed about the objective of the project, and, if interested in cooperating, are asked a series of standardized questions regarding the accuracy of water types identified on the FPA, the timing of the operation, and access and logistics details. A written record of the telephone conversation is filed. Often, a meeting with the landowner is arranged to discuss the project and the potential study site(s).

2. If timing of forest practices occurring in the vicinity of streams appears acceptable, arrangements are made to visit the site. Maps and aerial photos of the study site are obtained and relevant information is recorded on the field reconnaissance form.

3. Upon arrival at the potential study site, locate and confirm the water types, noting any apparent water typing errors. If suitable waters are present, investigate land use interferences and evaluate whether any interferences are so great as to preclude using the site. Use best professional judgement as to whether cumulative effects of past and present activities such as forest practices, grazing, and mining will interfere with site-specific BMP effectiveness assessments. The site must also be evaluated as to whether the forest practice activities are or will be conducted in compliance with the applicable forest practice rules. Consider road alignments, marked RMZ boundaries, information on the FPA, etc., and consult with DNR or Ecology regional office staff as necessary to resolve any questions about compliance.

4. If typed waters are located within or adjacent to the BMP-affected area and any impacts from past and current land uses are acceptable, proceed to evaluate the availability of a "reference/control" area or reach of stream. A reference area would be one outside the forest practices unit boundary with stream reaches that have similar physical characteristics as the potential treatment stream reaches. Ideally, stream order, gradient, dominant channel substrate, and overall channel morphology will be similar between the two reaches in order to more readily compare changes between them. Evaluate whether a suitable control reach exists

immediately upstream of the forest practices unit boundary on the same stream as the treatment reach. In general, treatment and control reaches are considered similar if they: 1) are in the same channel morphology class (per Channel Condition Survey methodology); 2) are in the same peak flow response category (per Channel Condition Survey methodology); and 3) the relative percent difference (RPD) of the average channel gradients between the two reaches does exceed 50% RPD, where RPD is the range of reach gradients expressed as a percent of the mean gradient.

5. If site selection criteria identified above are met, the study site is accepted. The study site is rejected if one or more of the criteria are not met.

6. Slope measurements are taken which are used to determine the slope hazard category from the sample stratification scheme. The slope hazard category is determined separately for road and harvest BMPs, according to the following protocols:

For Road BMPs: For determining Slope Hazard Category, slope measurements in percent are taken using a clinometer above and below the road at all stream and drainage swale crossings within the study segment of the road. Measurements are taken directly along the fall line from the top of upper stream banks (*i.e.,* extreme high water mark) for a slope distance of 30-60 meters or to the first significant slope break. All measurements taken at stream/drainage crossings of the road are averaged to determine average slope for the site, which is recorded on the field form. The maximum side slope gradient at the stream crossing(s) which are the focus of planned surveys is used to determine the slope hazard category for sample stratification.

For Harvest BMPs: For determining Slope Hazard Category, slope measurements in percent are taken using a clinometer within the stream valley along the treatment reach (*i.e.,* the reach within the harvest unit). Measurements are taken directly along the fall line from the top of upper stream banks (*i.e.,* extreme high water mark) for a slope distance of 30-60 meters or to the first significant slope break. Slope measurements are taken in the upper, middle and lower portions of a length of stream equal to about 25 active channel widths. If the harvesting practice will be on both sides of the stream, then slope measurements are taken on both sides. All measurements taken are averaged to determine average slope for the site, which is recorded on the field form. The maximum side slope gradient measured within the stream valley of the treatment reach where surveys are planned is used to determine the slope hazard category for sample stratification.

7. Available examples of targeted BMPs, and potential surveys that appear feasible to evaluate the effectiveness of the BMPs, are noted on the field form, and potential study reaches for in-stream surveys are identified before leaving the site.

FIELD RECONNAISSANCE FORM

Note: Attach Unit Maps and Photos   Accept Study Site: (Y or N)

DATE: ______________________ SURVEYORS: ______________________________________

Section ______________ Township ______________ Range ______________ Site Id # ______________________

FPA # __________ Landowner __________________________ Unit Name ______________________________

LandownerOffice/Address ____

LandownerContact/Phone# ____

AccessNotes (keys, driving directions) ____

____

Physiographic Region ______________________________ Ecology Region __________________________

BMPs Proposed ____

BMPs Completed (Yes or No) Date of Completion ____

Comments on Compliance: Meets Minimum BMPs (Y or N) ____

Hydrologic Events Since Completion ____

Watershed Analysis (yes or no)   Id Teams (yes or no)

% of Sideslopes Adjacent to Streams ____

Average Slope (%) ____________ Maximum Slope @ Study Reach ________________________________

Slope Form (Planar, Convergent, Divergent) ____

Slope Hazard Category (Based on Max. Slope) Road BMPs: L M H   Harvest BMPs: L M H

Geology\Parent Material ____

Soils ____

Sources for Geology/Soils ____

Water Types ____________________ Stream Orders ____________________ Flow Regime (High, Base, Dry)

Study Site Interferences (Other Land Uses, Ability to Isolate BMP, Prospects for Control Sites)

____

Similarity of Control and Treatment Reaches for In-stream Surveys:

Treatment: Morphology ________________ Response Category ______________ Gradient __________________

Control: Morphology __________________ Response Category ______________ Gradient __________ RPD: ________

Comments ____

____

____

____

SURVEY LIST:

In-Stream Surveys:

Channel Condition (CS), Photo Point Network (PS), Stream Bank Erosion (SE), Streambed Stability (ST), Channel Substrate Transects (SU), Runoff Sampling (RO), Macroinvertebrate Sampling (MI), Amphibian Sampling (AM)

Erosion/Sediment Delivery Surveys:

Photo Point Network (PS), Sediment Routing (SR), Culvert Condition (CC), Cutbank/Fillslope (CF), Road Surface Condition (RS), Erosion Pin Network (EP)

BMP LIST:

Harvesting: Tractor & Wheeled Skidding, Cable Yarding, RMZ, RLTA, Harvest w/o Buffer

New Road Construction: Culvert Installation & Temp. Stream Xings, Construction Techniques, Road Drainage Design

Road Maintenance: Active Haul Road Maintenance

BMP EVALUATIONS PLANNED:

Specific BMP to Evaluate:____

Surveys to Evaluate BMP:____

Specific BMP to Evaluate:____

Surveys to Evaluate BMP:____

Specific BMP to Evaluate:____

Surveys to Evaluate BMP:____

Specific BMP to Evaluate:____

Surveys to Evaluate BMP:____

Specific BMP to Evaluate:____

Surveys to Evaluate BMP:____

NOTES:____

____

____

Sediment Routing Survey

Purpose:

To evaluate surface erosion characteristics at sites with timber harvesting near streams or where RMZs and RLTAs are left as water quality protection measures. Specifically, to record the type, size, exposure, location, and proximity of surface erosion features to streams; to document whether sediment from surface erosion features is routed to streams over the study period; and to determine the relative extent of erosion and sediment delivery at the harvest site.

Materials:

extra fine point sharpies: blue, black, green, red
100 and 30 meter measuring tapes
metric carpenter's tape
clinometer
compass
lead pencils
clipboard
laminated aerial photo enlargements: scale 1:480
camera with 200 or 400 ASA print film
bright pink meter stick for scale
survey flags
write-in-the-rain field book
sediment routing field forms

Site Selection Criteria:

Sites selected for sediment routing surveys are sites with recently completed timber harvesting near streams, or sites where RMZs and RLTAs are left as water quality protection measures.

Method Summary:

Low altitude, large scale aerial photographs are obtained for selected BMP sites. Custom photography is flown by the Department of Transportation, usually at 1:4800 scale, and 10X enlargements (1:480) of selected areas are made. Initial photos and reconnaissance of the sites are conducted as soon as practical after timber harvest. Skid trails, water bars, yarding features, windthrow, wildlife trails, and other erosion features and drainage features within approximately 60-80 meters of stream banks are mapped and monitored. Selected erosion features are photographed. Residual evidence (*e.g.,* sediment plumes, gullies, channelization, hillslope storage sites) is evaluated in the field to make a determination of whether erosion features have delivered sediment to streams. All erosion features are measured and the degree of exposed soil is estimated during site visits. Erosion features within the survey area are mapped on the aerial photo enlargement. Sediment routing pathways between erosion features and drainage features may be noted on the photo map. Follow-up surveys are conducted over a one to three year period following harvest operations, to document chronic erosion and sediment delivery.

Assumptions:

Appropriately timed aerial photography and walking surveys of sites can be used to document surface erosion features, routes of sediment transport, locations of sediment storage, and sediment delivery to streams.

Delivery of sediment to streams from surface erosion features due to timber harvesting or yarding practices is a localized increase over background levels.

Near-stream zones are the most important sites for evaluating sediment delivery to streams from surface erosion associated with timber harvesting.

Survey Method:

1. Custom stereo aerial photos are taken by the Department of Transportation, usually flown at a scale of 1:4800. The timber harvest site plus upstream drainage areas are flown as soon as practical after the harvest operation has been completed. Near-stream areas to be surveyed are selected based on locations of BMPs targeted for evaluation; in some cases different harvest practices may be evaluated at the same harvest unit. Separate survey areas are selected for evaluation of harvest with stream buffers, harvest without stream buffers, cable-yarding, and ground-based yarding. Separate survey areas may also be selected to evaluate the same practice conducted in different parts of the harvest unit, if topography is highly variable.

2. Photos of selected survey areas within about 60-80 meters of streams are enlarged 10 times to a final scale of 1:480. In some cases, ground measurements between two identifiable points on the photos is taken to create scaled enlargements. Define outlines of the area to be surveyed on the initial 1:4800 aerial photo and on the 1:480 enlargements.

3. Use stereo pairs photographed at the 1:4800 scale for a preliminary office evaluation of the survey area(s). Identify skid trails, roads, drainage features, large erosion scars, and other features which are obvious on the photo and near the RMZ or type 1-5 stream margins. Use a mirror stereoscope with magnification to identify features.

4. Field Survey:
   a. During a fair weather survey (sharpies do not work in the rain!), walk the survey area from streams to the edge of any RMZ or RLTA and adjacent hillslope areas outside of any stream buffers. Focus the survey on those areas which have a reasonable potential to deliver

sediment from surface erosion to type 1-5 streams, generally areas within about 60-80 meters of streams, depending on local topography. Identify and number erosional features on the 1:480 enlargements, creating a photo map of the survey area. Look for skid trails, falling and yarding scars, windthrow, wildlife trails, etc., within the survey area that have exposed soil and meet the minimum size criteria, including those not visible on the aerial photos. Note the existing natural drainage features and streams within the unit on the aerial photos. Use different color sharpies to map different types of features. Draw the actual survey boundary on the enlargement as the survey proceeds (this will be used later to estimate the number of hectares surveyed).

b. Measure the length and average width of surface erosion features. Record the feature number, the type (skid trail, windthrow, road, yarding scar, wildlife trail, etc.), the length, average width, and estimated percent exposed soil for the feature in quartiles (*e.g.,* 0-25%, 26-50%, etc.). Indicate whether the feature is within 10 meters of a stream (measure to verify as needed), and whether any sediment has entered or is entering streams(based on residual evidence of sediment transport, such as gullies and sediment plumes, and in-stream deposition). Note sediment storage sites on the hillslope and features (surface obstructions, water bars, etc.) which may influence sediment delivery from the surface erosion feature. Draw surface sediment pathways from erosion features to streams and any drainage features not readily evident on the photo enlargement.

c. Take oblique angle photographs of selected erosion and depositional features of interest, using the pink 1 meter stick for scale, from good viewing locations such as the opposite stream bank or a stump; make sure the date-back feature on the camera is turned on. Note the location of the photo point and label it (A, B, C, etc.) on the enlarged laminated photo. Place a survey flag with photo point designation and date at the location from which the photos are taken. Record the photo point location, the feature photographed, frame numbers, etc. in a field book.

d. At selected erosion features that have sediment plumes extending towards a stream, mark the extent of sediment transport by placing survey flags along the down slope margin of fresh, loose sediment (*i.e.,* boundaries of the sediment plume). Stakes/flags are marked with the survey date, and used to establish changes in sediment transport over time.

5. Follow-up surveys are conducted over a one to three year period following timber harvest (depending on site and project considerations), using the same set of photo enlargements/map, or with a new set of enlargements, using the original survey map and notes for reference. In some cases, a new aerial photo may be taken and used to make enlargements for follow-up surveys. Preferably, any new photos should be flown at the same time of year as the originals. Make any new enlargements at the same scale as the first set.

6. On follow-up surveys, re-survey the site for erosion features; both new features and pre-existing features. Map any changes to the drainage features and sediment routing pathways, re-locate and re-measure the surface erosion features, estimate the degree of exposed soil, note if the features are within 10 meters of a stream, determine if features are continuing to deliver sediment to streams, and take oblique angle photographs of features of interest. Always re-photograph the

same views photographed in the original survey to document re-vegetation. Re-stake the margins of sediment plumes and measure the distance of sediment movement. Determine which features from the original survey are no longer eroding (based on minimum size criteria) and/or no longer delivering. If there is not time for a complete re-survey of the original survey area, then an alternative is to only re-survey harvest-attributable features which were found to deliver during the original survey in order to determine whether sediment delivery was chronic.

7. For selected features that are found to deliver, the volume of sediment delivered may be determined by measuring erosion volume (*e.g.,* surface area and depth of erosion, dimensions of gullies, rills, and slump blocks, etc.) and subtracting the volume of eroded sediment stored on the hillslope (*e.g.,* stored behind surface obstructions/slash or on topographic benches). When measuring erosion depth on skid trails, take care to differentiate between elevation change due to compaction and that due to erosion/gullying.

8. Data from each survey year are summarized separately. In addition to listing the data for each feature (*e.g.,* feature type, disturbed area, exposed soil area, proximity to streams, delivery), the relative extent of disturbed and exposed soil per hectare surveyed is calculated for: all erosion features, all features which delivered sediment to streams, and harvest-attributable features which delivered. The relative extent of amount of erosion may also be indexed to the length of stream bank surveyed. The follow-up surveys are used to evaluate chronic sediment delivery. The feature-specific data may be used to evaluate causes of sediment delivery, *i.e.,* the proportions of the total exposed soil area associated with delivered features that is attributable to different feature types.

Misc. Notes and Recommendations:

Aerial Photography Considerations

For sites that have stream buffers and for partial cut sites, consider the effects of shadows. Always have the photos flown at mid-day. North facing slopes need to have aerial photos taken when the sun angle is high (between spring and fall equinox) to reduce tree shading that may obstruct viewing the site features.

It is best to have photos flown as soon as possible after timber harvest is completed, unless snow cover obscures features on the ground.

For Department of Transportation aerial photo orders it is recommended that the following steps be taken: delineate the area to be flown on a USGS topographic map; list the management practices and expected completion date; and meet to discuss photo needs (scale, area, features, etc.) with the pilot.

Areas within RMZs are difficult to view from the air. Tree shading and/or narrow zones of disturbances make it necessary to delineate all erosional features during the walking field survey.

Guidelines for Minimum Feature Sizes Monitored:

Erosion Scars - greater than or equal to 3 meters in length and/or 2 square meters surface area.

Hillslope Storage Features and Deposits - greater than or equal to 1 square meter surface area.

In-stream Deposits - no minimum size, any obvious fresh deposits may be mapped and measured.

Data Analysis Note: For calculating erosion indices: 1) Disturbed Soil Area/Hectare: the measured area of disturbance (total up the surface area of all features measured) in m^2 is divided by the size of the survey area in hectares; 2) Exposed Soil/Hectare: the surface area (disturbed area) of each feature in m^2 is multiplied by an exposure factor corresponding to the midpoint of the range of exposed soil determined in the field (*e.g.*, 0-25% exposed soil = exposure factor of 0.125, 25-50% exposed soil = exposure factor of 0.375, etc.), to calculate exposed area for the feature. The exposed surface area for all features in m^2 is then totaled up and divided by the size of the survey area in hectares

BMP Effectiveness Rating:

Determination of BMP effectiveness using the sediment routing survey considers the evidence of continuing erosion with sediment delivery to streams. The BMP is considered effective if there is no evidence of chronic erosion with sediment delivery to a stream, that is attributable to physical disturbances during timber harvesting activities. Chronic refers to erosion with sediment delivery that continues beyond the first growing season for establishment of vegetative cover, or approximately one year.

Erosion features associated with windthrow of trees within buffers are documented but excluded from the determination of chronic sediment delivery directly attributable to harvest activities, in consideration of the beneficial functions of woody debris in streams, and because windthrow cannot necessarily be directly attributed to harvest practices.

This survey technique relies on residual evidence of erosion and sediment delivery (*e.g.*, sediment plumes, gullies or channel formation, etc.) and is not designed to detect minor amounts of erosion and sediment delivery as may occur during individual runoff events.

Sediment Routing Survey

Study Site # ________________ Date ________________

Site Name ________________ Time ________________

Survey ID # ________________ Surveyors ________________

Film Type __________

Film Speed __________

Camera Used __________

Weather __________

Study Site Description (drainage, etc.):

Feature #	Feature Type/Cause of Erosion e.g., Skid Trail, Yarding, Falling, Wildlife, Windthrow	Length (m)	Ave. Width (m)	w/in 10 m (y/n)	entering or in water (y/n)	Notes % Exposed Soil

Culvert Condition Survey

Purpose:

To evaluate erosion and sediment delivery associated with newly installed stream crossing culverts and culvert fills during the first one to three years after installation, to assess the overall stability of stream crossings, and to evaluate erosion downslope of relief culverts and whether road drainage and sediment are delivered to natural streams from relief discharges.

Materials:

map of forest practices unit (*e.g.,* from FPA)
camera with date-back feature
200 or 400 ASA print film
bright pink meter stick and half-meter stick (for scale)
100 meter measuring tape
clinometer
compass
culvert condition field forms and field book
lead pencils and sharpies
survey flags
copies of previous field notes and photos (on follow-up surveys)

Site Selection Criteria:

Sites selected for culvert condition surveys are segments of newly constructed roads that meet current BMP standards, where the initial survey can be conducted soon after BMP implementation and prior to impacts from a high intensity rainfall/runoff event.

Method Summary:

An initial evaluation of culverts is conducted as soon as practical after installation and prior to a high intensity rainfall or runoff event. Newly installed stream crossing culverts are monitored for effectiveness of armoring, vegetative cover and overall stability of culvert fills, and evidence of erosion at culvert sites. Culvert conditions at the time of surveys are documented using oblique angle photographs. Relief culverts are monitored to evaluate the disposition and effects of sediment and drainage discharged below their outfalls, including sediment transport distance and whether there is evidence of delivery to streams. The survey includes documentation of drainage distance and culvert spacing, road gradient, culvert plugging, elevation drop/downcutting at stream crossing culvert outfalls, and culvert skew. Follow-up surveys are conducted over a one to three year period following road construction, to evaluate chronic erosion and sediment delivery.

Assumptions:

Chronic erosion and sediment delivery from culvert installations can be detected by sequential surveys that visually and photographically document culvert conditions.

Delivery of sediment to streams at culvert installations is a localized increase over background levels.

Delivery of road drainage and sediment to streams from relief culverts through channelization or overland flow, or headward migration of a channel downslope of a relief drainage outfall following road construction, represents an expansion of the channel network and an increase over background levels of sediment delivery to streams.

The localized sediment delivery ratio for sediment generated from erosion of culvert fills at stream crossings is 100%. For road segments drained by relief culverts/cross drains, the localized sediment delivery ratio is less than 100%.

Surface erosion rates at road construction sites are highest within the first one to three years following road construction. Also, this erosion and associated sediment delivery may continue at a reduced rate for longer periods, if exposed soil is adjacent to stream crossings or within the contributing drainage area of relief discharges that deliver drainage to streams, particularly where gully erosion occurs.

Armoring of culvert fills (*e.g.*, with rock riprap) reduces surface erosion at stream crossings by protecting exposed soils from the erosive effects of flowing water and rain-drops, and adequate armoring can prevent erosion of the armored surface over the long term.

Survey Method:

1. Identify the culvert condition survey location on unit map and draw a sketch if necessary to ensure re-location of survey. Surveys will generally be conducted in a downslope direction (*i.e.* beginning at the highest point of the road segment), unless otherwise noted on the unit map and field notes. Notes indicating right and left side of the road are always read with the surveyors back to the start of the survey.

2. Complete the following survey information on the cover page of the field form:
Study Site ID (*e.g.*, O-03)
Survey ID (*e.g.*, CC01)
Brief Description of Road, Hillslope Features, and Location of Road
Date and Time
Surveyors
Film Type and Speed and Camera Used
Weather

3. Identify the first culvert to be evaluated on the site map and note the location on the field form. Number this culvert C1. Measure the distance, percent slope, and azimuth from the first culvert to the next one along the new road and number this culvert C2. If it is not possible to see the next culvert or it is farther than 100 meters, measure the distance, percent slope, and azimuth to a point in between and continue. Make a stopping point at road drainage divides. Also note waterbar locations.

4. Photograph the outflow, inflow, fill, ditchline, upslope, and downslope features at C1. Make sure the date-back feature on the camera is turned on.

5. Record the following information for the survey on the left page: from culvert #, to culvert #, distance, percent slope, azimuth, and culvert skew (for relief culverts). Distances, slopes, and azimuths are taken from the culvert labeled "from". On the right page record: frame #s for photos, % plugged, armoring effectiveness, extent of erosion, and feature description. Photo numbers and culvert condition ratings refer to the culvert in the "from" column. Armoring effectiveness rating categories are poor, fair, and good. Erosion rating categories are none, slight, moderate, and high. (Ratings for armoring and extent of erosion are defined in the following section.) Describe the photographed feature as an inflow, outflow, fill, ditchline, view upslope/upstream, or view downslope/downstream. For stream crossing culverts, note whether the culvert outfall is hanging above the streambed; for hanging culvert outfalls, measure the elevation drop to the streambed. As an option, estimates of the volume of erosion on culvert fills at stream crossings can be made by measuring the dimensions of gullies or slump blocks, and the depth (*e.g.,* as indicated by soil pedestals) and surface area of sheetwash erosion.

6. For relief culverts, note whether the culvert fully diverts ditch flow (*i.e.,* has a check dam in the ditch), or partially diverts ditch flow (*i.e.,* ditch flow continues past the culvert). Note whether there is formation of a distinct channel or overland flow sediment plume, or a pre-existing channel head, below each relief culvert outfall. Measure the sediment transport distance (*i.e.,* the distance of gullying/channelization and/or overland flow sediment plume extending downslope of the relief discharges). The hillslope gradient below the relief outfall may be measured with clinometer for future reference. For pre-existing channel heads, measure the distance from the channel head to the culvert outfall. Set stakes on either side of the channel heads located below the new road for future reference. Cross-section measurements of selected channel heads can be made for future reference. As an option for relief discharges that deliver to streams, estimates of the volume of erosion and sediment delivery can be made by measuring the dimensions of gullies developed in road ditches and/or below relief outfalls, and subtracting the volume of sediment stored on the hillslope. In some cases, the volume of in-stream deposits of fresh sediment can also be measured.

7. For waterbars encountered during the survey, number each waterbar and measure the distance from the last culvert or waterbar, and determine the disposition of drainage from the waterbar including whether it enters a stream. Note whether the waterbar diverts both ditch and travelway drainage, or only travelway drainage.

8. Proceed to the next culvert along the road. Take photos and record the location and culvert condition information as in steps 3-7. Continue moving along the road until the last culvert to be surveyed is reached. Record the location of the last culvert in the notebook.

9. Follow-up surveys are conducted over a one to three year period following road construction, depending on site and project considerations. Follow-up surveys are conducted with copies of the initial survey notes and with photos from previous surveys in hand. Refer to previous survey notes while conducting follow-up surveys in order to observe changes; refer to photos from previous surveys to photograph the same views along with any new features of interest. Original field notes taken during the initial survey are copied and left in the project files.

Misc. Notes and Recommendations:

The following ratings are applied to each culvert:

Extent of Erosion:

None = no evidence of erosion.
Slight = sheetwash erosion, a few small rills, etc.; <25% of the fill surface area is affected.
Moderate = rills and small gullies (<10 cm wide), minor amount of slumping or undercutting; 25-50% of the fill surface area is affected.
Severe = rills and small to large gullies (10 cm+ wide), substantial areas of slumping or undercutting; >50% of the fill surface area is affected.

Armoring:

Poor = little or no armoring; important fill locations not armored (*e.g.*, where water flow is directed), and/or rocks used are too soft or too small.
Fair = adequate rock, but inadequate protection beyond immediate area of culvert inflow/outflow; runoff may be diverted onto unprotected parts of fill.
Good = all important locations are armored with adequate rock.

General Photography Notes:

The photo frame seen through the lens may show more than is captured on or printed from the film. Shoot conservatively to capture as much of the feature as possible in the finished photo.

Try to show the entire fill area, including the road surface at the top of the photo. Step back to capture these features or take two pictures, one vertical and one horizontal. One very large or high fills, take photos of the fill from below and also from the road surface.

Place a scale at each feature to be photographed. Make sure to capture the entire length of the scale. Use either the half meter or the meter stick (bright pink) as needed. Suggested scale placement is horizontal for the culvert inflow/outflow, vertical for fill areas, and length wise down the ditch lines.

BMP Effectiveness Rating:

Determination of BMP effectiveness using the culvert condition survey considers evidence of continuing erosion with sediment delivery to streams, mass failure associated with the culvert installation, upslope migration of channel heads downslope of relief culvert outfalls, and delivery of sediment to natural surface waters via relief drainage.

The BMP is considered effective if there is no evidence of chronic erosion with sediment delivery to a stream, mass failure associated with the culvert installation, upslope migration of channel heads downslope of relief outfalls, or channelization or overland flow which routes relief culvert drainage to a live stream. Chronic refers to erosion with sediment delivery that continues beyond the first growing season for establishment of vegetative cover, or approximately one year. Effectiveness calls are made on individual culverts as well as the overall road segment (see "Decision Criteria for Culvert Condition Survey BMP Effectiveness Calls"). Stream crossings and relief culverts are rated separately.

This survey technique relies on residual evidence of erosion and sediment delivery (*e.g.*, sediment plumes, gullies or channel formation, soil pedestals, etc.), and is not designed to detect minor amounts of erosion and sediment delivery as may occur during individual runoff events.

Decision Criteria for BMP Effectiveness Calls on Culvert Condition Surveys

Observation at the Culvert	**Culvert-specific BMP Effectiveness Call**

Stream Crossing Culverts:

1. No chronic erosion with delivery to surface water.----------------------Effective

2. Chronic erosion with delivery to surface water*.-----------------------Not Effective

   * Exceptions made in the case of culverts with short fills (≤ 3m slope length at the outflow side of culvert) where erosion is observed to be reduced to *slight* by the second year, and cases where effective erosion control (*e.g.*, armoring) has eliminated the potential for continued erosion and second year erosion is negligible.

Relief Culverts:

1. No delivery to surface water (with or without channel initiation).-----Effective

2. Channel initiation with delivery to surface water.------------------------Not Effective

3. Overland flow with sediment delivery to surface water.----------------Not Effective

4. Upslope channel migration of pre-existing channel head.---------------Not Effective

Overall Site BMP Effectiveness Call

A separate site (*i.e.*, road segment) BMP effectiveness call is made for stream crossing and relief culverts according to the following scheme. If all the culverts installed were rated as effective then the site call is "Effective". If 50% or less of the culverts where rated ineffective the site call is "Partially Effective". If more than 50% of the culverts were rated ineffective, then the site receives an "Ineffective" call. A "Partially Effective" call does not imply that an individual culvert installation partially achieved the water quality objectives, but that some culverts did and others did not.

Culvert Condition Survey

Study ID #:____________________ Date:__________
Study Site Name:____________________ Time:__________

Survey #:______________ Surveyors:__________

Camera Used:
Film Type:
Film Speed:
Weather:

Starting & Ending Culvert #'s/Descriptions:

Road, Hillslope, etc.-Descriptive Notes:

Method Notes:

From:	To:	Distance:	Slope:	Azimuth	Culvert Skew

Frame #	% Plugged	Armoring Effectiveness	Extent of Erosion	Feature Description

Cutbank/Fillslope Survey

Purpose:

To evaluate the effectiveness of new road construction BMPs, from the standpoint of road cutbank and fillslope stabilization, ditch function, and erosion with sediment delivery to streams.

Materials:

map of forest practices unit (*e.g.,* from FPA)
100 meter measuring tape
compass
clinometer
metric survey rod
survey flags
camera with date-back feature
200 or 400 ASA print film
bright pink meter stick (for scale)
cutbank/fillslope field forms and field book
lead pencils and sharpie or grease pencil

Site Selection Criteria:

Sites are selected where new road construction is conducted near streams, and specifically at road segments draining directly to a stream crossing, where the initial survey can be conducted soon after BMP implementation and prior to impacts from a high intensity rainfall/runoff event.

Method Summary:

The survey is conducted on a segment of newly constructed road that drains directly to a stream crossing. A point line is established which runs along the base of the cutbank on the inside edge of the road, from the drainage divide to the stream and continuing to the drainage divide on the other side of the stream. At each point, oblique angle photographs are taken of road prism features. Initial photos and surveys are conducted soon after the road has been constructed and prior to a high intensity rainfall or runoff event. The cutbank, road surface, and ditch are photographed from the point line at the inside edge of the road. The fillslope is photographed by walking directly across the road from the established point line. Erosion and sediment storage features on sections of cut and fill slopes between each observation point are described to evaluate how the road prism stabilizes over the project study period. The percent gradient of the hillslopes above and below the road prism and the cutbank gradient are measured using a clinometer. Vegetative cover on slopes, types of erosion on cut and fill slopes (*e.g.*, sheetwash, gullying, mass erosion processes), extent of road surface rutting, and ditch erosion and sediment storage are some of the features described and photographed during this survey. Follow-up surveys are conducted over a one to three year period following road construction, to document chronic erosion and sediment delivery.

Assumptions:

Chronic erosion and sediment delivery from newly constructed road segments can be detected by sequential surveys that visually and photographically document the condition of road cutslopes, ditches, and fillslopes.

Delivery of sediment to streams at new road construction sites is a localized increase over background levels.

Over time, the localized sediment delivery ratio for sediment generated from cutbank and ditch erosion at road segments with direct entry ditchlines draining to streams approaches100%, unless sediment traps are present and functioning.

Surface erosion rates are highest within the first one to three years following road construction. Also, this erosion and associated sediment delivery may continue at a reduced rate for longer periods, if exposed soil is adjacent to stream crossings or within the contributing drainage area of ditches or relief discharges that deliver drainage to streams, particularly where gully erosion occurs.

Survey Method:

1. Complete the following site and survey information on the first page of the cutbank/fillslope survey field form:

Study Site ID (*e.g.,* E-02)
Survey ID (*e.g.,* CF01)
Brief Description of Road Segment Surveyed (referenced to the culvert number at the stream crossing if a culvert condition survey is conducted at same road), and Construction Practices
Date and Time
Surveyors
Film Type and Speed
Camera Used
Weather
Permanent Point Description

2. Identify the stream crossing of interest and determine the extent of the road segment draining to that crossing. Identify the survey location on unit map. Make sketch if necessary to ensure re-location of survey.

3. Select a permanent point for the start of the point line. Examples include: culverts, large stumps, large rocks that are unlikely to move, etc. Describe the features of the permanent point for future reference in the notebook. Use sketch if necessary. A photo may be taken from the permanent point. Make sure date-back feature on camera is turned on and set for the month/date/year mode. Record the object photographed, azimuth and distance from the permanent point in the notebook. Flag the permanent point and label it PP (for "permanent point") with the survey ID number.

4. Select the first observation point along the inside of the road. Measure the distance, percent slope, and azimuth from the permanent point to this first selected point. Place a survey flag above the cutbank in undisturbed soil wherever possible (otherwise place the flag in the cutbank near the location where the photographer stands) and label it P1. Include the survey number on all flags. Photograph one or more features, and record the photo frame number(s), feature description, azimuth, percent road gradient, and distance from point to point in the notebook.

5. Proceed to construct a point line (p-line) along the inside of the road, at the slope break into the ditch line. Points should be spaced about every 10-15 meters. At each observation point, photograph the cutbank, road surface, and ditch line from this perspective then walk directly across the road and photograph the fillslope. Descend down the fillslope as far as necessary to obtain the best perspective. Record each photo with subject and viewpoint notes. Place a survey flag with the point and survey ID number at each photo-point.

6. At each observation point along the p-line, visually estimate the cutbank slope length and classify as short (<3 m), medium (3-10 m), and high (>10 m) slope length categories (measure as needed to verify call), and measure the cutbank slope angle by laying the survey rod against the cutbank and determining the slope in degrees with the clinometer. Measure the percent gradient of the hillslope adjacent to the road prism at each point by taking clinometer readings above and below the road. The slope measurement should be taken from a point below any fillslope material to a point above the top of the cutbank.

7. Note the following road condition factors on the field form for the road segment between each point: percent exposed soil (in quartiles: 0-25%, 26-50%, etc.) covering the cutbank and fillslope; evidence of erosion (sheetwash erosion, tension cracks, slumps, rills, gullies); evidence of sediment storage (bench below road, slash berms, sediment traps, sills); presence of seeps on cutbanks; road travelway configuration (outsloped, insloped, crowned, water-barred, rutted); and ditch conditions. Describe other factors that influence surface erosion and road prism stability and sediment delivery to streams, such as erosion control practices (*e.g.,* hydromulch, riprap). As an option, estimates of the volume of erosion can be made by measuring the dimensions of gullies or slump blocks, and the depth (*e.g.,* as indicated by soil pedestals) and surface area of sheetwash erosion.

8. Continue moving along the road prism as outlined in steps 4-7 until the last observation point is established at the road drainage divide or ditch-diverting relief culvert. The road area surveyed should be only that segment of road that directly contributes drainage to a type 1-5 stream crossing.

9. Follow-up surveys are conducted over a one to three year period following road construction (depending on project and site considerations), and are used to evaluate chronic erosion with sediment delivery, and changes in road features that have occurred over the study period.

Misc. Notes and Recommendations:

Keep in mind that the final prints may not show the entire area inside the camera's viewfinder, shoot conservatively. Capture the entire scale when taking all photographs. Make sure the flat side of the scale is facing the camera.

On follow-up surveys: don't take the original survey field notes into the field; take copies from the site file; use prints (in protective sheets) or color photocopies of photos from previous surveys to ensure re-photographing the same views.

Road Cutbank Features:

Place observation points a maximum of 15 meters apart. Space points and select views that capture the entire section of cutbank between points. Lean the scale vertically on the cutbank, with the wide part facing the camera.

Road Fill Features:

Place observation points a maximum of 15 meters apart. Select photo views that capture the entire section of fillslope between observation points (*e.g.,* from the bottom of the fillslope, looking along the bottom edge of the constructed road prism, from a mid-slope position, or from turning points where the fill can be seen from the road edge). Take care not to disturb loose fill material if descending the fillslope. Lean the scale vertically on the slope, with wide part facing the camera.

BMP Effectiveness Rating:

Determination of BMP effectiveness using the cutbank/fillslope survey considers evidence of continuing erosion with sediment delivery to streams.

The BMP is considered effective if there is no evidence of chronic erosion with sediment delivery to a stream. Chronic refers to erosion with sediment delivery that continues beyond the first growing season for establishment of vegetative cover, or approximately one year. Cutbanks and fillslopes are evaluated separately for sediment delivery. The fillslopes may receive a rating of *Effective* if chronic delivery is limited to the immediate area of the stream crossing fill, where such delivery is considered in a culvert condition survey conducted at the same site.

This survey technique relies on residual evidence of erosion and sediment delivery (*e.g.,* sediment plumes, gullies or channel formation, etc.), and is not designed to detect minor amounts of erosion and sediment delivery as may occur during individual runoff events.

Cutbank/Fillslope Survey

Study Site # ____________ Date ____________

Site Name ____________ Time ____________

Survey ID # ____________ Surveyors ____________

Film Type ________

Film Speed ________

Camera Used: ________

Weather ________

Permanent Point Description:

From	To	Dist (m)	Azim	Road Grad	Hill Grad (%)	Cutbank Grad	Cutbank Slope Length

Frame #	Evidence of Erosion	Evidence of Storage	Seep (y/n)	Road Design (in/outslope)	Feature Notes % Exposed Soil

Erosion Pin Survey

Purpose:

To document the amount and rate of surface erosion on road cutbanks and skid trails, and to document amounts of sediment storage, in order to evaluate chronic sediment delivery where roads and skid trails contribute drainage to streams.

Materials:

map of forest practices unit (*e.g.,* from FPA)
notes from previous P-line or photo-point surveys to use in making a sketch of the site
metric carpenters tape
survey rod
100 and 30 meter measuring tapes
clinometer
erosion pins: 2-3 mm welding rods and/or 3/8" rebar stakes, 0.5-1 meter in length (depending on soil depth at site)
hammer to drive pins
ladder if needed for high cutbanks
survey flags
write-in-the-rain field notebook
erosion pin field forms
sharpie or grease pencils
lead pencils
copies of original network notes if re-surveying the erosion pin network

Site Selection Criteria:

Sites for erosion pin networks are selected at road or skid trail segments that contribute drainage directly to streams, or have drainage discharges within 60 meters of streams, where the initial survey can be conducted soon after BMP implementation and prior to impacts from a high intensity rainfall/runoff event.

Method Summary:

Erosion pin networks are placed along newly constructed road cutbanks or skid trails prior to a high intensity rainfall/runoff event. A cutbank/fillslope survey or a skid trail photo point survey is conducted before initial pin placement. Transects are placed every 10 meters within a contributing road or skid trail segment. A maximum of 10 and a minimum of 5 transects are placed along a representative portion of the contributing segment, covering a minimum of 10% of the contributing segment length. Pins are measured, placed, and the exposed length of the pin is recorded. The network is re-measured one or more times over a one to three year period, in order to document the depth of erosion and/or accretion.

Assumptions:

Erosion and any associated sediment delivery to streams from road cutbanks or skid trials represents a localized increase over background levels of sediment production and sediment delivery.

Surface erosion rates for new roads and skid trials are highest within the first one to three years following road construction or harvest activity, although erosion and any associated sediment delivery may continue at a reduced rate for longer periods.

Over time, the localized sediment delivery ratio for sediment generated from road or skid trail segments draining directly to streams approaches 100%, unless sediment traps are present and functioning.

Survey Method:

1. Complete the following survey site information on the first page of the field notebook:

Study Site ID (*e.g.*, E-02)
Survey ID (*e.g.*, EP01)
Brief Description of Features Surveyed, BMP evaluated, and Location of Survey
Date and Time
Surveyors
Weather
Permanent Point Description
Method Notes: length of segment; spacing of transects; etc.

2. Identify the survey location on the unit map. Using p-line notes from the previously conducted photo point or cutbank/fillslope survey, sketch the erosion pin network location within the contributing drainage segment and in relation to stream crossings and other site features. Select a segment that is a maximum of 100 meters in length and a minimum of 50 meters in length, keeping in mind that a minimum of 10% of the contributing drainage segment length should be covered by the erosion pin network.

3. Select a permanent point to be used for laying out the transects. Describe the features of the permanent point for future reference in the notebook, and show location on the site sketch map. Flag the permanent point and label it PP (for "permanent point") with the survey number.

4. Lay out the pin network and record network information as described in the following steps:

For Road Cutbanks:

a. Establish the network in a down-gradient direction. "Left" and "right" references in the notebook always refer to directions taken while looking down the road (down slope). Lay the 100 meter measuring tape down the center of the ditchline, starting at the permanent point. Transects are set every 10 meters along the tape. Place a survey flag in the hillslope above the location of the transect; label it T1 (transect 1).

b. Place pins 1 meter apart in a vertical transect on the cutbank, starting at the ditch centerline or base of cutbank along the inside of the road. At the top of the cutbank, place a pin at the bottom of the roots or vegetation and note the distance of the entire transect. Prior to pin placement, measure the entire length of the pin. After the pin has been placed, measure the exposed pin length. Note the pin # (1-n for each transect), total pin length, exposed pin length, and pin location on the right page of the field form. From the base of the pin placed at the bottom of the cutbank, measure and record the slope length and slope angle of the surface of the cutbank. Obtain the slope angle of the cutbank by laying the survey rod on the cutbank and taking a slope reading in degrees with a clinometer. Note the following information: transect number, slope of the cutbank, slope length of the cutbank, transect length, transect location, and flag placement information on the left page of the field form.

c. Place a flag near the location of the next transect, label it, and record the location in the field notes. Repeat step 4b, continuing down the road in this manner until the drainage segment is surveyed. Complete the sketch of the network showing placement of transects and pins.

For Skid Trails:

d. Establish the network in a down-gradient direction. "Left" and "right" references in the notebook always refer to directions read while looking down the skid trail (down slope). Decide upon which side the transects will start, right or left, and specify on the field form; if one side of the skid trail has a cutbank, start the transects on the opposite side, beginning at the outer edge of any fill. Lay the 100 meter measuring tape down the center of the skid trail, starting at the permanent point. Transects are set every 10 meters along the tape. Measure the slope (%) from the permanent point to the first transect, the transect length, and note the transect location and flag placement on the field form. Place a flag near the location of the transect, label it T1 (transect 1) noting which side of the trail it was placed. On the left page of the field form record: transect #, slope to next transect, transect length, transect location, and flag placement notes.

e. Place the pins 1 meter apart in a transect across the trail. At the far edge of the skid trail, place a pin at the bottom of the cutbank (if present), and continue the transect to the edge of exposed trail. For the last pin, note the distance from the previous pin in the "pin location" column. Prior to pin placement, measure the entire length of the pin. After the pin has been placed, measure the exposed pin length. On the right page of the field form record: pin # (1-n for each transect), total pin length, exposed pin length, and pin location. From the base of the pin placed at the bottom of any cutbank, measure and record the slope length and slope angle of the exposed surface of the cutbank. Obtain the slope angle of the cutbank by laying the survey rod on the cutbank and taking a slope reading in degrees with a clinometer.

f. Measure and record the slope gradient in percent to the next transect. Place a survey flag near the location of the next transect, label it, and record the location in the field notes. Repeat step 4e, continuing down the skid trail in this manner until the survey is finished.

5. During follow-up surveys conducted over a one to three year period (depending on site and project considerations), inspect the same pins and re-measure the length of exposed pin to determine erosion or accretion rates over time. (Accretion may be observed on portions of cutbanks or skid trails, especially at the base of cutbanks.) Note any pins that are not re-located during follow-up surveys. The depth of erosion/accretion may be used to estimate the volume of erosion and/or sediment storage along a road or skid trail segment.

6. Make and record observations (*e.g.,* evidence of transport and/or storage in road ditches, gullies/channelization or overland flow sediment plumes between skid trails and streams, etc.) to determine if eroded sediment is being routed to streams.

Misc. Notes and Recommendations:

The type of erosion pin used depends on the nature of the soil material at the site. A firm installation that does not disturb the soil is needed. In general, 3/8" re-bar stakes will work best for skid trail surfaces, and welding rods will work best on cutbanks.

A ladder may be needed in order to install and measure pins on high cutbanks without excessive soil disturbance.

BMP Effectiveness Rating:

Determination of BMP effectiveness using erosion pin networks considers evidence of continuing erosion with sediment delivery to streams. The BMP is considered effective if there is no evidence of chronic erosion with sediment delivery to a stream. Chronic refers to erosion with sediment delivery that continues beyond the first growing season for establishment of vegetative cover, or approximately one year.

Road Cutbank/Ditch Erosion Pin Network

Study Site #:____________________ Date:________
Study Site Name:________________ Time:________
EP#:_________________________ Surveyors:________

Weather:

Activity: Initial Placement

Interim Measurements

No. of Months Since Initial Measurement:

No. of Months Since Last Measurement:

Method Notes/Site Notes:

Transect #	cutbank slope (degrees)	cutbank length (m)	Transect Location

Pin #	Total Pin Length (cm)	Exposed Length	Pin Location Notes

No. 352

Skid Trail Erosion Pin Network

Study Site #:____________________ Date:________
Study Site Name:____________________ Time:________
EP#:____________________ Surveyors:________

Weather:

Activity: Initial Placement

Interim Measurements

No. of Months Since Initial Measurement:

No. of Months Since Last Measurement:

Method Notes/Site Notes:

Transect #	Slope to Next Transect	**transect length (m)**	Transect Location Notes

No 352

Pin #	Total Pin Length (cm)	Exposed Length	Pin Location Notes

Road Surface Condition Survey

Purpose:

To evaluate the effectiveness of active haul road maintenance BMPs by assessing the condition of the road surface during periods of high truck use and wet weather conditions.

Materials:

map of haul road segment and aerial photos (if available)
100 and 30 meter measuring tapes
metric carpenter's tapes
camera with date-back feature
200 or 400 ASA print film
survey flags
write-in-the-rain field book
lead pencils
road condition survey field forms
surface probe (metal rod) marked off in half-centimeter increments
2 hand-held traffic counters
rite-in-rain graph paper & scales
compass
clinometer
hand level & level rod
hand trowel & shovel
tipping bucket rain gage with pre-programmed datalogger

Site Selection Criteria:

Sites for this survey are selected along segments of active main haul roads that drain directly to a stream crossing, where the stream reach upstream of the road being evaluated is not crossed by a road within about 1 kilometer. Active main haul roads are defined as having traffic levels exceeding four log trucks per day.

Method Summary:

The surface conditions of main haul roads are assessed during wet weather surveys by sampling at transects established near a stream crossing. Conditions documented at each transect include condition of gravel surfacing, extent of fines/mud on the road surface, ruts and potholes, and microtopography of the road surface. Photographs are taken to document conditions at the transects. Surface drainage pathways are mapped along the study segment, and relative moisture condition of the road sub-surface is assessed. A qualitative assessment is made of cut and fill slopes and ditches, noting evidence of erosion, vegetative cover, and slope length and angle for the contributing road segment. Log truck and light vehicle traffic is counted during the survey period. In addition, recent maintenance history for the road is obtained from the landowner. Runoff sampling is often conducted in conjunction with (*i.e.*, on the same day) the road surface condition survey.

Assumptions:

The condition of the road surface during periods of heavy use in wet weather influences the production of fine sediments and delivery of fine sediment to streams.

Road surface conditions influencing fine sediment production from haul roads may be sampled directly during periods of heavy use in wet weather.

At stream crossings and along segments of haul roads with ditchlines draining directly to streams, the localized sediment delivery ratio is 100% for fine sediment that is mobilized by runoff.

Survey Method:

1. Install rain gage: Upon arrival at the site, install the tipping bucket rain gage in the vicinity, at a location free from overhead obstructions such as forest canopy. The datalogger should be pre-programmed to record tips at 15 minute intervals.

2. General Survey Information**:** On the first page of the road condition survey field form, the following general site and survey information should be recorded:

Study Site ID (*e.g.*, E-02)
Survey ID (*e.g.*, RS01)
Location and Name of Road
Date & Time (beginning and ending)
Surveyors
Weather Conditions
Length of contributing road segment
Gradient of road segment
Gravel type and source (obtained from landowner contact)
Road drainage design (inslope/outslope, crowned, etc.).
General description of road prism (cut/fill slopes, etc.)
Hillslope gradient above and below and road segment gradient

3. Sketch the study area and establish the road segment to be surveyed. Determine the contributing road segment, *i.e.*, that segment which drains directly to the stream crossing

(extends to road surface drainage divides and/or relief culverts that fully relieve ditch flow). Delineate the contributing segment and surface runoff drainage routes on the sketch of the study site. Show cutbanks, fillslopes, berms, and ditches on the sketch. Establish transects as described below in step 4, number the transects, and indicate the transects numbers on the sketch. Transects are generally numbered sequentially, from right to left (facing downstream from the crossing).

4. Establish road transects at 10 meter intervals, along a 100 meter segment of road centered on the stream crossing. This will result in 11 transects, with one at the center of the stream crossing and five on either side of the stream. At each transect, make the following measurements and observations, and note on the field form:

a. Condition of the gravel surface: At each transect, establish points at two meter intervals along the travelway, with a point at each edge (*i.e.,* outside of the travelway at shoulder or ditch). At each point, probe the surface with a metal rod and/or hand trowel and note whether there is a functional, compacted gravel surface. At the conclusion of transect measurements, make notes of general gravel layer conditions (*e.g.,* apparent thickness of gravel surfacing) and gravel type, size, etc. Verify gravel type and source with road maintenance personnel. Collect a gravel sample for later comparison with other study sites.

b. Thickness of mud/fines: At the same measurement points where gravel condition is assessed, determine the thickness of fines/mud on the surface by inserting a calibrated metal rod, and record thickness to the nearest half centimeter.

c. Extent of rutting or potholes: For each transect that has visible ruts or potholes, measure the width with tape and depth with hand level and rod.

d. For each transect, note the width of the travelway, whether the road surface is insloped or outsloped, and whether or not a corrugated "washboard" surface is apparent.

5. <u>Photograph each transect:</u> Establish photo-points to document the road surface and drainage characteristics. Photo-points are co-located with transects, although additional points may be included. Points are marked with survey flags at the edge of the right-of-way, with photos taken from the points as well as from offset locations on the road. Frame numbers of photos are noted in the "Comments" column of the transect notes.

6. <u>Road surface drainage mapping:</u> Where runoff is apparent, make a scaled drawing of surface water pathways on the road prism, including ruts, ditches, and drainage diversions. Include portions of the contributing road segment which are outside of the part sampled by transects.

7. <u>Assessment of road cuts and fills, culverts, and ditches:</u> Based on a walking survey of the contributing road segment, make a qualitative assessment of the condition of road cuts and fills, noting the slope length, slope angle, degree of cover, extent of surface erosion, etc. Describe the condition of drainage ditches and culverts. These features may also be

documented by photo-points where they are outside of the portion of the road sampled by transects. Evaluate the entire contributing road segment and assess the similarity of the intensively sampled portion to the remainder of the contributing segment.

8. Traffic count: During the field survey period, count each vehicle that passes the survey segment. Use one hand-held counter for log trucks and other heavy vehicles (*e.g.,* dump trucks) and one for light (*i.e.,* 4-wheel) vehicles. At the end of the survey period, note the number of vehicles of each type on the field form. In addition, obtain truck traffic data (*e.g.,* from trip tickets, best estimates) for the 30 days prior to the survey from the landowner.

9. Maintenance Information: Obtain best available maintenance records for the 6 months prior to survey from the landowner (interviews with maintenance personnel, etc.)

10. Moisture level: In the field, visually determine the relative soil moisture of the road sub-surface layer, immediately below the gravel surface, by probing several locations along the road segment sampled, and categorize the soil material as dry, moist, or saturated according to the following classifications:

- saturated: infiltration capacity is exceeded, runoff or standing water is apparent;
- moist: precipitation is infiltrating, with no apparent standing water;
- dry: fine material crumbles in palm of hand, minimal moisture.

BMP Effectiveness Rating:

The integrity of the gravel surface, extent of surface fines and muddiness, the degree of rutting, potholes and other surface irregularities, surface runoff drainage patterns, and turbidity of runoff are indicators of BMP effectiveness. The BMP is considered effective if there is no evidence of fine sediment production leading to sediment impacts on receiving waters. Such evidence may include surface muddiness or rutting within a contributing segment, with fine sediment routed to the stream; active cutbank or ditch erosion within a contributing segment; and/or visible sediment plume extending downstream during runoff events. Results of runoff sampling are also considered where such sampling is conducted in conjunction with the road surface condition survey.

Road Surface Condition Survey Field Form

Study Site ID ____________ Date: ____________

Survey ID RS-________ Road Name/Location ____________

____

Time: Start ____________ End ____________

Weather ______________________

Length of Road Surveyed (Meters) ____________

Gradient of Study Segment % ____________

Gravel Type ______________________

Gravel Source ______________________

Road Drainage Design (inslope/outslope, etc.) ____________

____

General Description of Road Prism (cut/fill, etc.) ____________

____

Hillslope Gradient Above and Below Road (%)

Range ____________ Average ____________

Traffic Count: Beginning Time: ________ End Time ________

Log Trucks Light Vehicles

Soil Moisture: Saturated Moist Dry

Comments:

Transects Placed at 10 meter intervals

Transect #	Point #	Functional Gravel Surface (Y/N)	Fines Thick. (cm)	Rutting/Potholes Width (m)	Rutting/Potholes Edge Elev. (m)

Rutting/Potholes Bottom Elev.	Rutting/Potholes Edge Elev.	Rutting/Potholes Depth (m)	Inslope/ Outslope	Wash-board Y/N	Comments

Channel Condition Survey

Purpose:

To qualitatively characterize stream channel and aquatic habitat conditions within control and treatment reaches, and evaluate changes in study reaches over time, including before and after timber harvest or road construction.

Materials:

map of forest practices unit (*e.g.,* from FPA) and aerial photo (if available)
100 and 30 meter measuring tapes
metric carpenter's tape
survey flags
channel condition field forms and clipboard
lead pencils and field book
clinometer
substrate viewer (*e.g.,* viewing tube with plexiglass lens)
scaled substrate probe or ruler

Site Selection Criteria:

Channel condition surveys are conducted at sites where new road construction or timber harvest practices are implemented near streams, where initial surveys can be conducted prior to in-stream impacts from the forest practice under evaluation, and preferably where a control reach is located upstream of or nearby the treatment reach.

Method Summary:

Initial assessments of the control and treatment reaches are conducted prior to any in-stream impacts from the forest practices under evaluation. For surveys evaluating road construction, it may be necessary to conduct the preliminary survey concurrent with or immediately following road construction in order to accurately identify the crossing location and study reaches. The study reach is generally 25 times the average active channel width in length. The reach is walked and the conditions of the channel bed and banks are closely observed, taking notes on sub-reaches. After walking the reach one or more times, a channel condition form is completed and scored. Follow-up channel condition surveys are conducted over a one to three year period following forest practice operations.

Assumptions:

Gross changes in stream channel conditions, including stream bank stability, in-channel sediment storage, and substrate characteristics, can be documented by observations made in sequential qualitative surveys of channel features over the project study period.

The magnitude, rate, and type of change in channel conditions in representative control reaches represents a baseline condition against which changes in treatment reaches can be compared, and certain differences may be attributed to the effects of forest practice activities.

While small, steep streams may ultimately function as sediment transport reaches over geomorphologically relevant time scales, they function as sediment storage sites and aquatic life habitat over biologically relevant time scales.

Maintaining natural regimes of stability for stream banks, channel substrates, and sediment storage elements such as large woody debris is important for maintaining beneficial uses.

Survey Method:

1. The survey is conducted during low flow conditions. Identify the survey location on unit map and aerial photo (if available).

2. Measure a minimum of three representative average active channel widths on the study reach and multiply by 25 to obtain reach length; minimum length is 20 channel widths for longer reaches. In some cases, the study reach may be longer than 25 channel widths. Note the reach length on the channel condition form. If channel characteristics such as confinement, stream gradient, or dominant channel bed or bank material indicate a substantial change in channel response potential, a new study reach should be described. Set a survey flag and tie ribbons at the beginning and end of the reach.

3. Walk the study reach one or more times and observe conditions of the channel bed, banks, and other items listed on the channel condition form. Take gradient measurements between two people throughout the reach using a clinometer, measure the distance of the reading, and note in the field book. Gradient for the reach is calculated as a weighted-average of measurements taken along the reach (weighted by the distance of each measurement). Active channel and valley bottom width are generally measured at each stopping point while walking the reach for gradient measurements. Valley wall slope angles are also measured.

4. Complete the channel condition assessment of the study reach by circling or filling in the field form. When filling out the form, refer to notes of observations made at the sub-reach level. The channel condition field form has been adapted from the methodology developed by Metzler (1992). The channel morphology classification used was developed by Montgomery and Buffington (1993) as part of the TFW CMER Program.

5. Follow-up channel condition surveys are conducted over a one to three year period after the completion of forest practice operations (depending on site and project considerations), and are

used to determine changes in channel features that have occurred over the study period in control and treatment reaches. Where possible, follow-up surveys are conducted during the same season and at similar flow regimes as the initial survey.

Miscellaneous Notes and Recommendations:

Take notes in the field book while measuring gradient, width, etc., indicating channel conditions within each segment of the study reach. Take notes at the sub-reach level on bank condition, substrate composition, pool condition, armoring, extent of fresh sediment deposits, etc. to use in filling out the channel condition form after surveying the entire reach. Carefully observe substrate conditions within each sub-reach using the substrate viewer, and probe to determine depth of fine sediment in pools.

BMP Effectiveness Rating:

Determination of BMP effectiveness related to in-stream impacts considers the type and magnitude of change in stream bank disturbance, sediment deposition and channel substrates, sediment storage elements, and streambed stability/mobility in the treatment reach, relative to changes in the control reach. Elements of the channel survey form that document observed stream response to sediment inputs or physical disturbances are scored, while other observations are used to describe the channel's response potential (based on morphology, etc.) or cause/effect relationships. This survey technique is intended to document gross level changes in stream channel condition; minor changes or effects may not be detected.

The BMP is considered effective if there is no evidence of an increase in bank erosion, sediment deposition or destabilization of sediment storage elements or the streambed that is attributable to the forest practice.

The BMP is rated ineffective if the channel condition score decreases by $\geq$ 10 points as a result of forest practice effects. Where a paired control reach was used, the net change in treatment reach score is considered (Δ in treatment minus Δ in control). Where no site-specific control reach is available, an ineffective call requires that the score decrease by $\geq$10 points, and that the percentage decrease in score exceeds the greatest percentage decrease in score observed in any control reach from the study. A partially effective call may result if the treatment reach score decreases by $\geq$ 10 points initially and channel conditions recover during subsequent surveys.

References:

Metzler, J. 1992. Stream Channel Conditions Assessment, A Methodology to Evaluate Channel Damage Related to Increased Peak Flows. Jones and Stokes Associates. Bellevue, Washington.

Montgomery, D.R. and J.M. Buffington. 1993. Channel Classification, Prediction of Channel Response, and Assessment of Channel Condition. Department of Geological Sciences and Quaternary Research Center, University of Washington. Seattle, Washington.

CHANNEL CONDITION SURVEY
ECOLOGY SEDIMENT BMP STUDY

Study Site ID #: ____ Study Site Name: ______________________________ Reach # (@ site): _____ Channel Cond. Survey #: CS-_____

DNR Water Type: ___ Stream Order: ___ Ave. Active Channel Width:_____ m Ave. Wetted Width: _____ m Reach length: _____ m

Date: ______________________ Flow today is (relative to HWM): **High** **Moderate** **Low** **Dry** Q meas:______ cfs/l-s
Surveyors:

Walk the study reach and observe the conditions of the channel bed and banks. Length of the study reach should be at least 20-25 active channel widths. If conditions such as confinement of the channel, stream gradient, or dominant channel bed or bank material change significantly, then a new reach should be described. Take notes on key channel condition elements every 10 meters or so throughout the reach. After walking the reach, fill in the blanks and circle the responses that best describe the average conditions within the channel. If none of the conditions fit, supply comments to describe how the channel condition deviates from the response circled. If applicable, more than one response can be circled for an item. Unless otherwise noted, the score is averaged for items where more than one response is circled.

Survey Description:
Preliminary Survey: Y / N BEFORE / AFTER Forest Practice Operation CONTROL or TREATMENT Reach

Approx. Date of Forest Practice Operation _________

Reach Location:

I. FACTORS AFFECTING CHANNEL RESPONSE

A. Channel Morphology Classification (from Montgomery & Buffington, 1993):
a. BEDROCK c. CASCADE e. PLANE-BED g. REGIME
b. COLLUVIAL d. STEP-POOL f. POOL-RIFFLE h. BRAIDED

B. Landscape Position of Reach:
a. Bench b. Uninterrupted Sideslope c. Main Valley Floor d. Other:______________________

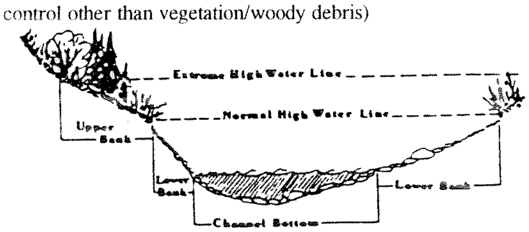
C. Channel Constraint:
- Average active channel width = _________ meters
- Average valley bottom width = _________ meters VBW/ACW = _________

- Valley Form: a. **V**-shaped b. **U**-shaped (narrow alluviated) c. **Wide** alluviated d. **Flat** (very wide or no valley walls)

D. Channel Bed/Bank Parent Material:
Source of material: a. alluvium b. glacial till c. colluvium d. hard bedrock (e.g. volcanic)
e. soft bedrock (e.g. sedimentary) f. lacustrine h. other ____________________

E. Primary Controls on Stream Banks:
a. Bedrock Control b. Boulder Control c. Erodible Soil Banks (no control other than vegetation/woody debris)

F. Stream Energy:
Average channel gradient of reach = ______ %
Is the profile "stairstepped"? Yes No
If yes, what forms the steps? Bedrock Boulders Woody debris
Do the steps appear stable? Yes No



From flow chart, peak flow response category is:
Type A: unconstrained
Type B: slightly constrained, unconsolidated bottom
Type C: laterally constrained, unconsolidated bottom
Type D: constrained, bedrock/large boulder
Type E: boulder/bedrock stairstep
Type F: woody debris stairstep

II. CONDITION OF CHANNEL BANKS

A. Channel Capacity:

0-4 pts* 1. Response Category Type A or B (channels with floodplains):
- **4 pts** a. active channel carries average annual flood, larger events spread across floodplain
- **2 pts** b. active channel has downcut or widened, so peak flows rarely spread over the floodplain
- **1 pt** c. active channel has downcut and/or widened to the extent that peak flows never spread over the floodplain; an inner terrace has developed within the "blownout" channel area, marking a new active channel
- **0 pts** d. a major flood has passed through and caused obvious damage in this channel

0-4 pts* 2. Response Category Type C, D, E, F (channels without floodplains):
- **4 pts** a. active channel appears adequate to carry average annual flood; streamside vegetation comes down to active channel margin
- **2 pts** b. active channel area shows signs of enlargement, raw banks indicate some widening or downcutting; there is a flood-disturbed area that is greater than the active channel width
- **1 pt** c. channel appears "blownout"; active channel area is much smaller than the flood-disturbed area within the valley bottom
- **0 pts** d. a debris flow or flood has obviously come down this channel and caused damage

*** NOTE: only one category scored--choose IIA1 *or* IIA2.**

B. Degree of Existing Bank Erosion:

1. Percent of reach length with Bedrock/Boulder (i.e. non-erodible) Banks:

    a. 1-25%   c. 51-75%

    b. 26-50%   d. > 75%

0-6 pts 2. Percent of reach length with Eroding Banks:

a. 1-25%	**6 pts**	c. 51-75%	**2 pts**
b. 26-50%	**4 pts**	d. > 75%	**0 pts**

0-4 pts 3. Location of bank erosion:

4 pts a. nowhere in reach

3 pts b. in expected places, such as outside of bends and constrictions

0 pts c. in unusual places, such as straight stretches and inside of bends

0 pts d. upper banks

4. Apparent cause of erosion (based on visual evidence):

    a. flowing water   c. heavy equipment   e. large animals (elk, cattle, etc.)

    b. windthrow   d. tree falling/yarding   f. other: ____________________

5. Angle of banks exposed by erosion:

    a. vertical: |_| b. angled back: _/   c. undercut:/__\

6. Angle of <u>un</u>exposed banks:

    a. vertical: |_| b. angled back: _/   c. undercut:/__\

7. Upper Bank Condition:

Has the stream undercut the upper banks?	Yes	No
If yes, has this resulted in mass wasting?	Yes	No
Is there evidence of a high rate of soil creep?	Yes	No

C. Degree of Bank Protection:

1. Predominant type of vegetation along the banks: (circle more than one if mixed)

    a. mature coniferous trees
    b. mature hardwood trees
    c. immature conifers 6-18 meters tall
    d. immature conifers 2-6 meters tall
    e. recent clearcut, trees <2 meters tall
    f. immature hardwood trees
    g. shrubs
    h. grass

2. Vegetation density:

    a. banks are well protected by a deep, dense root network, which is inferred from the dense, mature (well-established) forest
    b. banks are fairly well protected by deep roots with several open areas
    c. banks are protected by a dense but shallow root network, inferred from the dense, young trees or shrubs
    d. banks are poorly protected by a shallow root network with numerous openings
    e. banks receive little or no protection from roots

D. Resistance of Lower Bank Material:

1. Bank cohesion (kick the bank!):

    a. resistant bedrock
    b. erodible bedrock
    c. cohesive silt/clay resistant to erosion
    d. cemented matrix of fine material containing rock particles
    e. cohesive but erodible silt/clay
    f. noncohesive assortment of mostly cobble and larger sizes
    g. noncohesive assortment of mostly cobble to gravel-size rocks
    h. noncohesive assortment of mostly gravel-size rocks
    i. noncohesive assortment of mostly fine material

2. Bank Rock Content

    a. 0-40%
    b. 40-90%
    c. >90%

E. Flow Deflection into Banks (focus on thalweg):

0-4 pts

4 pts a. little or no deflection of flows into banks

4 pts b. a few areas where flow is deflected into the banks by logs, boulders, or the channel meander pattern

0 pts c. numerous areas where flow is deflected into channel banks by logs, boulders, or the channel pattern

III. CONDITION OF CHANNEL BOTTOM

A. Deposition:

0-6 pts 1. Extent of bottom affected by fresh deposits (i.e. loose, unarmored, unvegetated masses of sediment without algal staining). Look closely for signs of vegetation establishing itself; consider all size classes in active channel area, not just wetted area:

- **6 pts** a. very few fresh deposits (<10%)
- **4 pts** b. 10-25% of bottom area with fresh deposits, a few isolated pockets behind storage elements (e.g. boulders, woody debris) or small point bars
- **2 pts** c. 25-50% of bottom area with fresh deposits (i.e. several small point bars, many pockets behind boulders or woody debris.
- **1 pt** d. 50-75% of bottom covered with fresh deposits, such as large mid-channel or point bars; deposits common in pools; many moderate to large sediment wedges.
- **0 pts** e. >75% of bottom covered with fresh deposits

2. Size of dominant material in fresh deposits:
   - a. most particles cobble-size and larger
   - b. most particles are gravel to cobble-size
   - c. particles are mostly gravel with some finer material
   - d. particles are mostly fines (< 6mm--fine gravel, sand and smaller sizes)

3. Pool Types:
   - a. No pools in reach (generally a Cascade or Plane-Bed morphology reach)
   - b. Pool types in reach: i. Plunge Pools ii. Scour Pools iii. Dammed Pools

0-8 pts 4. Deposition in Pools:

- **4 pts** a. Pool substrate mostly gravel and/or cobble (< 25% surface fines)
- **2 pts** b. Moderate amount of fines in pools (25-75% of surface area)
- **0 pts** c. Pool substrate mostly fines (> 75% of surface area)
- d. Depth of fines in pools: i. < 5 cm **4 pts** ii. 5-10 cm **2 pts** iii. >10 cm **0 pts**

0-6 pts 5. Percent of bottom area within depositional zones <u>other than pools</u> (riffles, bars, sediment wedges) covered by fines (<6mm):

- a. 0-25% **6 pts** c. 51-75% **2 pts**
- b. 26-50% **4 pts** d. >75% **0 pts**

0-6 pts 6. Sediment Storage Elements (associated w/ sediment wedges):

- a. Type of sediment storage elements: i. LWD ii. Boulders iii. Other (explain):________________
- b. Do storage elements appear stable, as evidenced by moss, staining, vegetation, etc.? i. Yes **6 pts** ii. No **0 pts**
- c. Do storage elements appear to have been destabilized?
  i. No ii. A few destabilized elements iii. many or most elements destabilized

B. Evidence of Recent Bed Mobility:

0-6 pts

- **6 pts** a. in all but channel thalweg, rocks are "dull"; bed materials show definite staining, algae growth, or have clinging vegetation; bed materials are never or only rarely mobile
- **4 pts** b. throughout the channel, there is a mix of "bright" and "dull" rocks; staining or algae growth or clinging vegetation is evident in some places
- **2 pts** c. mostly "bright" rocks; some staining or algae growth or clinging vegetation is evident in sheltered backwater areas
- **0 pts** d. nearly all "bright" rocks; there is no evidence of staining, algae growth, or clinging vegetation; majority of bed materials appear to be quite mobile during high flows

C. Armoring (pick up some rocks and look at subsurface particles):

- a. Within the wetted channel (or bottom of streambed), are surface particles distinctly larger than subsurface particles?
  Yes No
- b. On bars, are surface particles distinctly larger than subsurface particles?
  Yes No

D. Particle Packing (kick the bottom!):

- a. larger particles are surrounded by smaller or overlapping ones, creating a tightly packed substrate resistant to scour
- b. some overlap and particle packing, larger rocks can be moved with your foot but smaller particles create a tightly packed matrix resistant to erosion
- c. larger particles are surrounded by a loose matrix of smaller particles
- d. bottom is very loose, most particles can be moved with your foot

E. **0-6 pts**

Pts	Dominant Particle Sizes:	Subdominant Particle Sizes:
3 pts*	a. bedrock	a. bedrock
3 pts*	b. large boulders	b. large boulders
3 pts*	c. small boulders	c. small boulders
3 pts*	d. cobble	d. cobble
3 pts*	e. gravel	e. gravel
0 pts*	f. fines (fine gravel, sand, silt)	f. fines (fine gravel, sand, silt)

Particle Size Classes:

Large Boulder:	>512 mm
Small Boulder:	256-512 mm
Cobble:	64-256 mm
Gravel:	6-64 mm
Fine Gravel:	2-6 mm
Sand & smaller:	<2 mm

*** Score one choice only for dominant, <u>plus add 3 pts for any selection of subdominant particle size, 0 pts for no subdominant size.</u>**

F. Angularity:

a. substrate consists mostly of flat or angular rocks resistant to rolling
b. substrate consists mostly of subangular rocks, some flat or rounded rocks present
c. substrate consists mostly of rounded rocks that have little resistance to rolling

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IV. WOODY DEBRIS

0-6 pts* A. Location of Woody Debris:

6 pts a. individual logs within or adjacent to the wetted channel area
6 pts b. clumps or jams within or adjacent to the wetted channel area
3 pts c. clumps or jams along the outer margin of the active channel area
3 pts d. individual logs along the outer margin of the active channel area
1 pt e. most of the logs have been deposited above and outside of the active channel area
1 pts f. a debris jam blocks the channel
0 pts g. numerous debris jams block the channel
0 pts h. numerous logs have been deposited within this reach from upstream
0 pts i. there are no logs in or adjacent to the channel

*** Score only one selection (highest point value) that reflects the predominant condition.**

0-6 pts* B. Size/Origin of Woody Debris:

6 pts a. Predominantly large (>25 cm) & Natural
3 pts b. Predominantly small (<25 cm) & Natural
3 pts c. Predominantly large (>25 cm) Logging Slash
0 pts d. Predominantly small (<25 cm) Logging Slash

*** Score only one selection (highest point value) that reflects the predominant condition.**

V. OTHER CHARACTERISTICS

A. Culverts and Bridges:
Describe culverts or bridges within or near the study reach (size, condition, armoring, capability for handling flood flows and debris)

C. Known History of Flooding or Debris Flows:
Note date, magnitude of flood event, probable cause, source of information

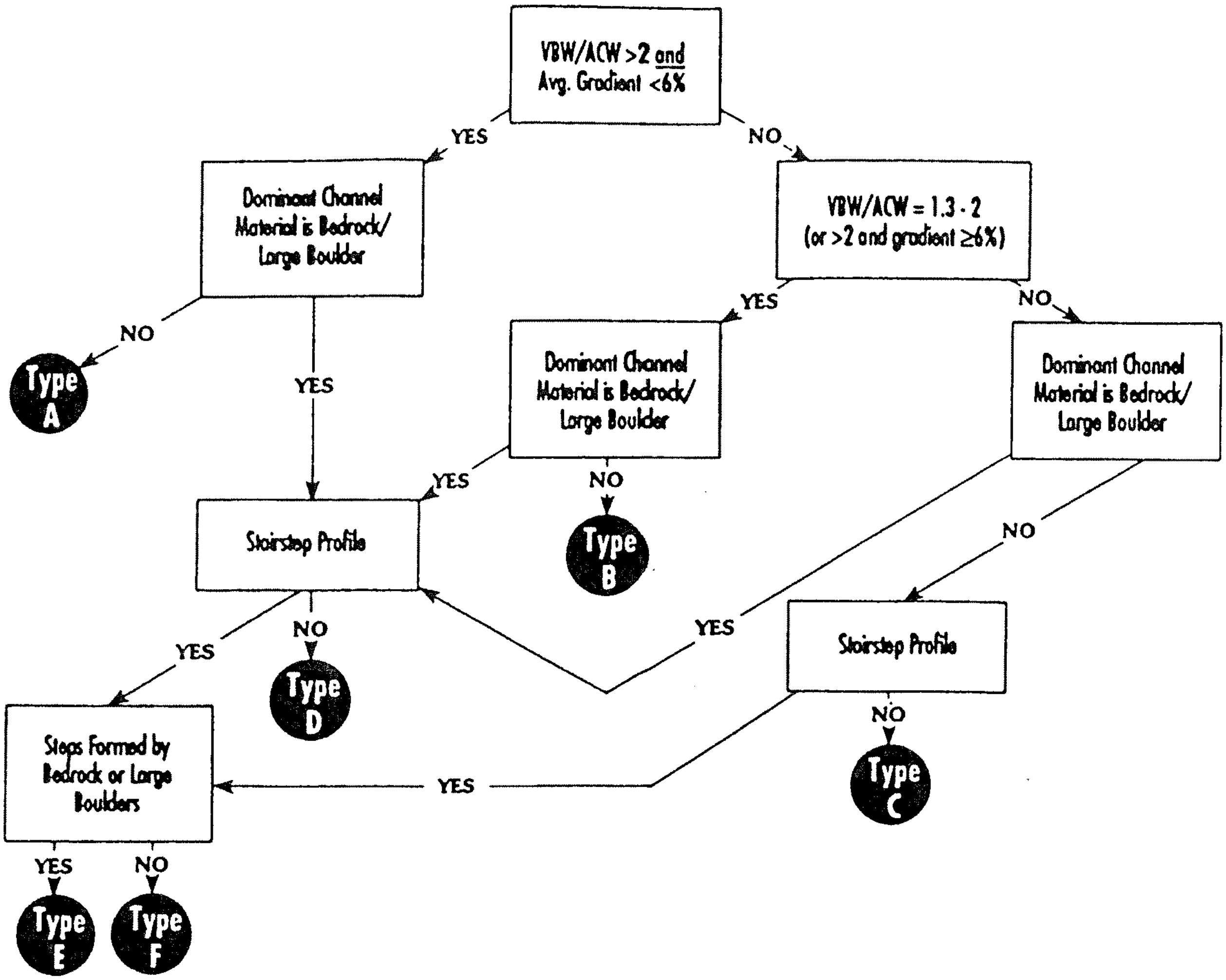
D. Other Observations:

	REGIME	POOL-RIFFLE	PLANE BED	STEP-POOL	CASCADE	BEDROCK	COLLUVIAL
Typical bed material	sand	gravel	gravel/cobble	cobble/boulder	boulder	-	colluvium
Bedforms	multi-layered	laterally oscillatory	none	vertically oscillatory	none	discontinuous alluvium	-
Reach Type	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	sinuosity, large scale edies and turbulence, bedforms (dunes, ripples)	bedforms (bars, pools, riffles), grains, LWD, sinuosity, local turbulence	grains, local turbulence	bedforms (steps, pools) causing hydraulic jumps & turbulence, grains, LWD	grains, hydraulic jumps, and local turbulence	structure controlled steps & obstructions	grains, LWD
Dominant Sediment Sources	fluvial/ bank failure/ inactive channel	fluvial/ bank failure/ inactive channel/ debris flows/	fluvial/bank failure/ debris flows	fluvial/ hillslope/ debris flows	fluvial/ hillslope/ debris flows	fluvial/hillslope debris flows	hillslope/ debris flows
Sediment Storage Elements	overbank bedforms inactive channel	overbank bedforms inactive channel	overbank inactive channel	bedforms, pool-filling sediment	Lee & stoss sides of flow obstructions	-	bed
Typical Slope (m/m)	S < .001	.001 < S < .01	.01 < S < .03	.03 < S < .08	S > .08	-	-
Typical Confinement	unconfined	unconfined	unconfined	confined	confined	confined	confined
Pool Spacing (channel widths)	5 to 7	5 to 7	none	1 to 4	none	variable where present	-

General reach-level channel type characteristics.

SOURCE: Montgomery and Buffington, 1993

Flow Chart for Determining Response Category Type



RESPONSE CATEGORY TYPE	POTENTIAL RESPONSE TO INCREASED PEAK FLOW
Type A: Unconstrained	Increased width and meander wavelength through bank cutting; may also downcut
Type B: Slightly constrained, unconsolidated bottom	Increased width through bank cutting; this may result in undercutting of the upper banks and accelerated mass wasting; may also enlarge by downcutting
Type C: Laterally constrained, unconsolidated bottom	Most likely to downcut; may also increase width through bank cutting, which could trigger accelerated mass wasting of upper banks
Type D: Constrained, bedrock/large boulder bottom and banks	Cannot enlarge through downcutting, may widen slightly where banks can erode; will transmit water, sediment, and debris to lower reaches
Type E: Boulder/bedrock stairstep	High stream energy will transport water, sediment, and debris to lower reaches; if upper banks are not bedrock, may widen slightly and accelerate mass wasting
Type F: Woody debris stairstep	If "steps" are stable, will respond as Type E, or may trigger debris flow/dam break flood if debris recruitment is high and "steps" fail

SOURCE: Metzler, 1992

Photo Point Survey for Stream Channels and Skid Trails

Purpose:

To establish photo points that visually document stream channel and skid trail characteristics and features, and to record point lines along stream channels and skid trails in a way that allows the same photo points to be re-surveyed so that changes over time can be documented with sequential photos.

Materials:

map of forest practices unit (*e.g.,* from FPA) and aerial photo (if available)
camera with date-back feature
200 or 400 ASA print film
30 and 100 meter measuring tapes
compass
survey rod
bright pink meter stick, for scale
bright pink half meter stick, for scale (in smaller streams)
survey flags
write-in-the-rain field book
photo point survey field forms
sharpie or grease pencil
lead pencils

Site Selection Criteria:

Sites for stream channel photo point networks are selected where new road construction and/or harvest activities are conducted near streams, where initial surveys can be conducted prior to in-stream impacts from the forest practice under evaluation, and preferably where a control reach is available either upstream or nearby the treatment reach. For skid trail photo point networks, sites are selected where initial surveys can be conducted soon after BMP implementation and prior to impacts from a high intensity rainfall/runoff event.

Method Summary:

Oblique angle photographs are taken of stream channels or skid trails. Initial photos of stream channels are taken prior to any in-stream impacts from the forest practices under evaluation. For surveys evaluating road construction, it may be necessary to conduct the preliminary survey concurrent with or immediately following road construction in order to accurately identify the crossing location and study reaches. Initial photos of skid trails are taken as soon as practical after BMP implementation. Photos are taken along a point line established so that subsequent surveys can be conducted using the same viewpoints. Erosion, sediment storage, and other features are photographed to document changes in skid trail or channel conditions over the project study period. Stream banks, channel substrates, sediment wedges, boulder clusters, and woody debris/windthrow are some of the stream features photographed during this survey. The survey may be used to document numbers of new windthrown trees which cross the stream over the study period. Skid trail surfaces, water bars, cutbanks, vegetative cover, and sediment transport routes are some of the skid trail features photographed during this survey. Follow-up photo point surveys are conducted over a one to three year period following forest practice operations.

Assumptions:

Gross changes in stream features, including channel bed and bank conditions, can be documented by sequential photo surveys over the project study period.

The magnitude, rate, and type of change in channel conditions in representative control reaches represents a baseline condition against which changes in treatment reaches can be compared, and certain differences may be attributed to the effects of forest practice activities.

While small, steep streams may ultimately function as sediment transport reaches over geomorphologically relevant time scales, they function as sediment storage sites and aquatic life habitat over biologically relevant time scales.

Maintaining natural regimes of stability for stream banks, channel substrates, and sediment storage elements such as large woody debris is important for maintaining beneficial uses.

Certain types of skid trail erosion and associated sediment delivery to streams, and re-vegetation of skid trails, can be documented by sequential photo surveys over the project study period.

Delivery of sediment originating from skid trails to streams is a localized increase over background levels.

Survey Method:

1. The survey is conducted during low flow conditions. Identify the survey location on unit map and aerial photo (if available). Use sketch if necessary to ensure re-location. In-stream photo surveys are generally co-located with channel condition survey reaches; if applicable, note the channel condition survey ID on the map.

2. Note the following survey information on the first page of the field form:

Study Site ID (*e.g.*, E-02)
Survey ID (*e.g.*, P01)
Brief Description of Features Surveyed, BMP evaluated, and Survey Location
Date and Time
Surveyors
Film Type and Speed
Camera Used
Weather
Permanent Point Description

3. Select a permanent point near the start of the photo point network. Examples include: culverts, large stumps, large rocks that are unlikely to move, etc. Describe the features of the permanent point for future reference in the notebook. Use sketch if necessary. A photo may be taken from the permanent point. Make sure date-back feature on camera is turned on and set for the month/date/year mode. Record the object photographed, azimuth and distance from the permanent point in the notebook. Flag the permanent point and label it PP (for "permanent point") with the survey number.

4. Select a feature or segment to be photographed and the best view for the photo point. Measure the distance, percent slope, and azimuth from the permanent point to this first selected point. For skid trail photo surveys, place photo points a maximum of 15 meters apart. Place a flag on or near the location where the photographer stands and label it P1 (photo point 1). Include the survey number on all flags. If it is not possible to place a flag where the photographer would stand, record the location in relation to the photo point (*e.g.*, "standing 1 meter in from right bank flag"). Place the bright pink meter stick in the photo view for scale. Take photos of one or more features and record the following information in the notebook:

Stream Photo Surveys:

Information is to be recorded on facing pages. On the left page record: from point #, to point #, distance, azimuth, and percent slope (these measurements are taken from point to point, while standing at the center of the stream channel). On the right page record for each photo taken: frame #, telephoto (y/n), stereo pair (y/n), and feature description. Describe the photo technique if other than standing (crouching, etc.), and note location of the viewpoint relative to the flag placement and the subject photographed (*e.g.*, looking downstream at right bank disturbance).

Skid Trail Photo Surveys:

Information is to be recorded on facing pages. On the left page record: from point #, to point #, distance, azimuth, and percent slope. On the right page record for each photo taken: frame #, telephoto (y/n), stereo pair (y/n), estimated percent vegetative cover on the skid trail surface (in quartiles: 0-25%, 26-50%, etc.), evidence of erosion (gullies, rills, slumps, soil pedestals, etc.), and skid trial design/construction (insloped, outsloped, cut/fill, bermed, etc.). In the "Notes" column, record evidence of sediment storage and erosion prevention measures (water bars, slash, hill slope benches), downslope sediment transport routes, and evidence of sediment delivery to streams. Place the points so that water bars are visible in photographs and the distances between water bars is documented. Describe the photo technique if other than standing (crouching, etc.), and note location of the viewpoint relative to the flag placement and the subject photographed.

5. Select the next feature or segment to be photographed and the best view for the photo point. Measure the distance, percent slope, and azimuth along the stream or skid trail centerline from the previous point to this next selected point. Place flag, take one or more photos, and record information in the field notebook as in step 4.

6. Continue moving along the point line being established until the survey is finished. For photo surveys in streams, the reach length to be surveyed equals roughly 25 times the active channel width. Label the final point as "Px, EOS (End Of Survey)" on the field flag and in the notebook.

7. Follow-up photo point surveys are conducted over a one to three year period following the completion of forest practice operations, depending on site and project considerations. Where possible, subsequent surveys are conducted during the same season and under similar flow conditions as the previous surveys. Always take a set of photos and notes from previous surveys to refer to when conducting follow-up surveys, in order to orient the photographer and ensure photographing the same view from each photo point. The original notes and photos can be used to re-locate photo-points if flags are lost. Note observed changes from previous photographs while in the field (*e.g.,* "two new windthrown trees between P2 and P3"). Subsequent surveys are used to determine changes in features that have occurred over the study period. For stream surveys where buffers (RMZs or RLTAs) are evaluated and at control reaches, sequential photo sets can be analyzed to document the number of new windthrown trees which cross the stream channel over the course of the study period.

Miscellaneous Notes and Recommendations:

General Photography:

Capture the entire scale (one meter or one-half meter) when taking all photographs. Make sure the flat side of the scale is facing the camera.

Keep in mind that the final prints may not show the entire area inside the camera's viewfinder, shoot conservatively.

For follow-up surveys, take prints in plastic sheets or color photocopies from previous surveys and re-shoot the same views for comparison. The scale should be placed in the same location as in previous surveys. Never take the original photo survey field notes into the field. Take copies from the site file only.

Stream Bank Features:

Shoot from center of stream channel, upstream, adjacent to, or downstream of stream bank. Place the scale vertically on high banks, horizontally on long, low banks.

Sediment Wedge Features:
Take the photos while looking downstream, preferably from an elevated position such as boulder or bank. Place the scale along the width of the sediment deposit.

Sediment Storage Elements:
Take the photos while looking upstream. Place the scale vertically against the storage mechanism (*e.g.,* LWD, boulder cluster) to give a sense of the feature's height.

Channel Substrate and Morphology:
Take photos of streambed features/substrate conditions looking both downstream and back upstream as the network is built. Try to capture the channel cross-section features. Place the scale horizontally across the stream.

Skid Trail Features:
When taking photos of water bars, place the scale vertically on the water bar, leaning back along the slope distance. When taking photos of skid trail surfaces, place the scale horizontally across the width of the skid trail, tilted so that the wide part of the scale is facing the camera.

Skid Trail Cutbank Features:
Lean the scale vertically on the cutbank, with the wide part facing the camera.

BMP Effectiveness Rating:

Determination of BMP effectiveness using the stream photo point survey considers the relative magnitude and type of change in stream bank erosion, sediment deposits, and in-channel sediment storage elements in the treatment reach relative to that in the control reach, based on photo interpretation and direct field observations. The BMP is considered effective if there is not evidence of an increase in bank erosion, sediment deposition, or destabilization of the streambed or sediment storage elements such as large woody debris, that is attributable to forest practice activities. (See attached guide for photo point survey effectiveness criteria.)

Questionnaire forms are used to compile observations made in comparing year to year changes at individual photo points within stream reaches, to document numbers of new windthrown trees crossing the stream, and to compare changes observed in treatment reaches to changes in control reaches. (See attached examples of these questionnaires.) This survey technique is intended to document gross level changes in stream channel condition and to supplement the Channel Condition Survey. Minor changes and effects may not be detected.

Determination of BMP effectiveness using the skid trail photo surveys considers evidence of continuing erosion with sediment delivery to a stream. The BMP is considered effective if there is no evidence of chronic erosion with sediment delivery to a stream. Chronic refers to erosion with sediment delivery that continues beyond the first growing season for establishment of vegetative cover, or approximately one year.

Decision Criteria for BMP Effectiveness Calls on In-Stream Photo Point Surveys

For Surveys with Control Reach:

EFFECTIVE:	For features evaluated on rating form, any observed changes are approximately equal in treatment and control reaches, or greater in control.
PARTIALLY EFFECTIVE:	For features evaluated on rating form, adverse changes observed are moderately greater in the treatment reach, but may also be present in the control reach, and changes in the treatment reach can be attributed to forest practice effects.
INEFFECTIVE:	For features evaluated on rating form, adverse changes observed are substantially greater in the treatment reach, and either not evident or slight in the control reach, and changes in the treatment reach can be attributed to forest practice effects.
INDETERMINATE:	Interference due to effects from other activities (un-related to the forest practice under evaluation), or photo quality is inadequate to make valid before-after and/or control-treatment comparison.

For Surveys with no Paired Control Reach:

EFFECTIVE:	For features evaluated on rating form, there is no evidence of adverse changes in the treatment reach.
PARTIALLY EFFECTIVE:	For features evaluated on rating form, there is evidence of moderate degradation in the treatment reach that can be attributed to forest practice effects.
INEFFECTIVE:	For features evaluated on the rating form, there is evidence of substantial degradation in the treatment reach that can be attributed to forest practice effects.
INDETERMINATE:	Interference due to effects from other activities (un-related to the forest practice under evaluation), or photo quality is inadequate to make valid before-after comparison.

Stream Photo Point Network

Study Site # ______________ Date ______________

Site Name ______________ Time ______________

Survey ID # ______________ Surveyors ______________

Film Type __________

Film Speed __________

Camera Used: __________

Weather __________

Permanent Point Description:

From: To: Distance: **Azimuth**: Slope:

Frame #	T	S	Description - Direction of Photo - Notes

Skid Trail Photo Point Network

Study Site # ____________ Date ____________

Site Name ____________ Time ____________

Survey ID # ____________ Surveyors ____________

Film Type ____________

Film Speed ____________

Camera Used: ____________

Weather ____________

Permanent Point Description:

From: To: Distance: **Azimuth:** Slope:

Frame #	T	S	% Veg Cover	Erosion Evidence	Trail Design (cut/fill, etc.)	Notes

In-Stream Photo Point Survey Summary

Site: Survey dates:

Survey Id: Treatment or Control Reach?

Water Type: Reach Length:

Indicators of in-channel changes	Yes	No	Photo/Field Notes References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?						
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?						
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?						
4. Is there evidence of increased deposition or storage of fine or coarse sediment?						
5. Are there changes in woody debris? Increase in large WD? Increase in small WD Decrease in WD?						
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?						

Summary:

(Indicate major changes observed in the elements above (refer to photo points), sediment sources and causes as noted in field notes or from photos, explanation of effectiveness rating, and other observations such as windthrow, observations of fish use, etc., as well as any comments on photo quality.)

BMP Effectiveness Rating:

In-Stream Photo-Point Survey Comparison Summary

Site: Survey Years:

Study Reach Descriptions:

Indicators of in-channel changes	Control PS-__ Yes	Control PS-__ No	Treatment PS-__ Yes	Treatment PS-__ No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?				
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?				
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?				
4. Is there evidence of increased deposition or storage of fine or coarse sediment?				
5. Are there changes in woody debris? (indicate numbers of windthrown trees documented over the survey period) Increase in large WD? Increase in small WD? Decrease in WD?				
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?				

Summary:

(Indicate major changes observed in the elements above (refer to photo points), sediment sources and causes as noted in field notes or from photos, explanation of effectiveness rating, and other observations such as windthrow, observations of fish use, etc., as well as any comments on photo quality.)

BMP Effectiveness Rating:

Skid Trail Photo Point Survey Summary

Site: Survey dates:

Survey Id:

	Yes	No	Photo/Field Notes References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?						
2. Is there evidence of gully development or other chronic erosion problems? 3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters?						
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?						
5. Is there evidence that skid trails are re-vegetating? 6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.* , other than natural re-vegetation)?						

Summary:

(Indicate major changes observed in the elements above (refer to photo points), sediment delivery, gullies, etc. as noted in field notes or from photos.)

BMP Effectiveness Rating:

Stream Bank Erosion Survey

Purpose:

To measure characteristics of stream bank erosion and document the number, type, and extent of bank erosion features in treatment and control reaches, and to evaluate changes in the extent of stream bank erosion over time.

Materials:

field notes for photo-point survey of the study reach (to generate "P-line" map of study reach)
"rite-in-the-rain" graph paper for making sketch
metric carpenters tape
field notebook
stream bank erosion survey field forms
pencils
30 and 100 meter measuring tapes
35 mm camera with telephoto and date-back features
400 ASA print film
random number generator

Site Selection Criteria:

Study reaches are selected at timber harvest or road construction sites, where initial surveys can be conducted prior to in-stream impacts from the forest practice under evaluation, and preferably where a control stream reach can be located upstream of or nearby the treatment reach.

Method Summary:

Stream bank maps are drawn to scale, sections of eroding banks are numbered, and the total bank length is measured. Measurements are made of the length and surface area of eroding banks within the study reach. Measurements include bank length, height, and percent exposed surface. The apparent cause of bank disturbance is noted. Preliminary surveys are conducted prior to forest practice-related impacts on stream banks within the treatment reach, other than localized disturbance at newly constructed road crossings. For surveys evaluating road construction, it may be necessary to conduct the preliminary survey concurrent with or immediately following road construction in order to accurately identify the crossing location and study reaches. Follow-up surveys measure length and surface area of eroding banks along the same stream reaches over a one to three year period following forest practice operations.

Assumptions:

Changes in the magnitude and rate of stream bank erosion may be detected by sequential measurements of eroding stream banks within a study reach.

The magnitude and rate of change in stream bank erosion observed in representative control reaches provides a baseline against which changes in treatment reaches can be compared, and certain differences in erosion may be attributed to the effects of forest practice activities.

Accelerated bank erosion can degrade aquatic habitat and destabilize stream channels.

Stream bank erosion is a natural process that can be accelerated by certain forest practices which directly or indirectly (*i.e.,* through changes in streamflow regimes) disturb stream banks.

Survey Method:

1. The survey is conducted during low flow conditions. Study reaches are approximately 25 channel widths in length. Within each of the study reaches, stream bank erosion features are initially identified during the establishment of a photo-point network in the stream channel. The photo-point network measurements are used to establish the point-line from which the channel centerline is mapped. After the plan view centerline sketch is made, a 100 meter tape is fixed along the centerline and the locations of all eroding banks are noted on the sketch along with the approximate outline of the stream bank perimeter. On this sketch, centerline length is to scale, but channel width is not necessarily drawn to scale.

2. Measure the total stream bank length on each side of the stream by running a flexible measuring tape (*e.g.,* fiberglass tape) along the top edge of the bank over the length of the reach, and record right bank and left bank lengths separately on front page of field form.

3. Eroding bank features are numbered sequentially, in the order encountered, as B1, B2, etc., with the bank location and number noted on the sketch. Indicate the approximate length of eroding stream bank on the sketch next to the bank number. The location of the beginning and ending points of the bank feature, in meters from the top of the reach along the centerline, is also noted on the sketch as well as the field notes form.

4. If there are less than 10 eroding stream banks within the reach, sample each feature. If there are more than 10 eroding stream banks, randomly choose at least 10 stream banks for a sub-sample, or sample all eroding banks in the reach.

5. Beginning with B1, measure the physical dimensions of each feature sampled and record on the field form:

a. Measure the length of actively eroding bank (bare soil or partially bare) by running a tape along the top edge of the bank. (See below, the definition of eroding bank used for this survey.)

b. Measure the height of the eroding stream bank at 25%, 50%, and 75% intervals along the total length. At each measurement point, height is the cumulative height of exposed bank face, excluding areas of boulders and moss or other vegetative cover. Measure height as slope length from the top edge of bank to the streambed transition, curving the tape underneath any overhang in order to measure the entire exposed surface.

c. Visually estimate the % of total bank surface area that is exposed soil (*i.e.,* not covered by vegetation, moss or boulders) as 0-25%, 26-50%, 51-75%, or 75-100%.

d. Indicate bank shape (angled in, angled out, or vertical) on the field form.

e. Other comments about a bank, including the apparent cause of bank disturbance (*e.g.,* scour by flowing water, timber falling/yarding, windthrow, wildlife activity) should be noted in the comment column of the form.

6. Take one or more photographs of the eroding stream bank from the center of the channel; note frame number(s) in field notes.

7. Continue down the stream channel in this fashion until the end of the study reach or until at least 10 banks have been surveyed. Be sure to note the total length of the reach surveyed.

8. Follow-up surveys are conducted over a one to three year period following forest practice operations, depending on site and project considerations. During follow-up surveys, the same numbered bank features are re-located and re-surveyed. If any previously identified features are no longer actively eroding, this is noted. Any new features not present in previous surveys are noted on an updated sketch, and these new features are also surveyed.

Miscellaneous Notes and Recommendations:

Eroding banks are defined as stream banks with exposed soil that can be influenced by flowing water (either through scour, undercutting, or mass wasting) during moderate and/or high flow events. Eroding banks are influenced such that woody plants, herbaceous vegetation, moss and/or other hydrophilic plants have been scraped, sloughed, or scoured off, or are unable to grow, and/or grasses and other plants, litter, etc. from above the wetted channel have been scoured away or removed by direct mechanical disturbance. Bank cover may have been removed either by flowing water or other physical disturbance. Active erosion refers to erosion above the normal low water level. (Note: exposed soil along an eroding bank should be visible without lifting grass or root mats for viewing; undercut banks without associated upper bank failure must be tall enough to be viewed without lifting grass and/or root mats originating from above the active channel.)

BMP Effectiveness Rating:

Determination of BMP effectiveness considers the magnitude and rate of change in stream bank erosion in the treatment reach, in terms of absolute change or relative to that in the control reach. The BMP is considered effective if there is no evidence of an increase in the magnitude or rate of stream bank erosion that is attributable to the forest practice. (See decision criteria for BMP effectiveness calls.)

Decision Criteria for BMP Effectiveness Calls on Stream Bank Erosion Surveys

There are two scenarios for making BMP effectiveness calls with the stream bank erosion survey. Scenario #1 involves those study sites that have paired control and a treatment reaches for before/after comparisons. Scenario #2 is for sites where only a before and after treatment reach was established, without a site-specific, paired control reach. The method for dealing with these two scenarios is as follows:

Scenario #1:

If the net increase (over any increase observed in the control reach) in the length of eroding bank is $\leq$ to 1% of total stream bank length, the BMP is rated "Effective".

Erosion that can be attributed to the forest practice operation (*e.g.*, yarding activities) and resulted in a net increase of > 1% of total bank length over any increase observed in the control reach, will result in a "Not Effective" call.

Scenario #2:

If any increase in stream bank erosion is $\leq$ 5% of total bank length between pre- and post-treatment surveys, the BMP is rated "Effective". If the cause of erosion is attributable to the forest practice operation (*e.g.*, yarding activities) and bank erosion increases by > 5% of total stream bank length from pre- to post- treatment, then the call is "Not Effective". (The 5% rate of increase is a conservative criteria based on an assessment of stream bank erosion at all control sites evaluated statewide.) If the cause of bank erosion can only be attributed to sources not directly associated with the forest practice operation (*e.g.*, scour by flowing water), the BMP is rated "Effective".

(NOTE: While all causes of bank erosion are surveyed, bank erosion associated with windthrow is not considered to be a net degradation for purposes of the BMP effectiveness rating, in consideration of the beneficial effects of large woody debris in streams, and furthermore, because windthrow cannot necessarily be directly attributed to the forest practice operation.)

Stream Bank Erosion Survey Field Form

Study Site ID # ______________________________

Study Site Name ______________________________

Stream ID ______________________________

Surveyors ______________________________

Date ______________ Reach # ______________

Survey #: SE- ______________ Resurvey: Yes No

Map Updated: Yes No

Total # Eroding Banks in Reach ______________

Total # Sampled ______________

Total Reach Centerline Length (m) ______________

Left Side (LDS) Right Side (LDS)

Total Length of Banks (m) ______________ ______________

Total Length of Eroding Banks (m) ______________ ______________

Comments:

Bank #	Length from Top of Reach (meters)	Bank Length (meters)	Height 1	Height 2	Height 3	Ave	% Exposed	Shape /_\ _/ |_|	Frame #:	Comments:

No. 352

Streambed Stability Survey

Purpose:

To measure and evaluate the number, size, volume, and stability of streambed sediment deposits and associated sediment storage elements within treatment and control reaches, and to evaluate changes in channel sediment storage features over time.

Materials:

hand compass
metric carpenter's tape
7 meter telescoping level rod
hand level
30 and 100 meter measuring tapes
"rite-in-the-rain" graph paper (5 squares to the cm.)
streambed stability field forms and field book
5/8" re-bar stakes
random number generator
pencils
survey flagging

Site Selection Criteria:

Study reaches are selected at timber harvest or road construction sites, including sites where RMZs or RLTAs are left as a water quality protection measure, where the initial survey can be conducted prior to in-stream impacts from the forest practice under evaluation. A control reach is generally located immediately upstream of the treatment reach, or on a nearby stream. This survey technique is most appropriate for stream reaches with step-pool or step-cascade channel morphology.

Method Summary:

Major stream channel features within treatment and control reaches are plan-view mapped using a rod and tape method. Obstruction-formed sediment deposits (*i.e.,* sediment wedges) and associated sediment storage elements (*e.g.,* LWD, boulder clusters) are identified and measured throughout the reach. Surveys are conducted during low flow conditions to identify and monitor changes in the number, size, volume, and stability of these streambed sediment storage features. Initial surveys are conducted prior to any in-stream impacts from the forest practices under evaluation. Follow-up surveys are conducted over a one to three year period following the forest practice operations to document and compare changes in control and treatment reaches in terms of the volume of sediment stored, and the number of sediment wedges and stability of sediment storage elements.

Assumptions:

Changes in the number, size, volume, and stability of in-channel sediment deposits can be measured by sequential surveys of sediment storage sites and associated channel features.

The magnitude, rate, and type of change in streambed conditions in representative control reaches represents a baseline condition against which changes in treatment reaches can be compared, and certain differences may be attributed to the effects of forest practice activities.

While small, steep streams may ultimately function as sediment transport reaches over geomorphologically relevant time scales, they function as sediment storage sites and aquatic life habitat over biologically relevant time scales.

Maintaining natural regimes of stability of sediment storage elements such as large woody debris is important for maintaining beneficial functions within streams, including aquatic habitat uses. Furthermore, streambed obstructions in headwater streams play an important role in long-term sediment routing through forested drainage basins (Megahan, 1982).

Survey Method:

1. The survey is conducted during low flow conditions. Study reaches are generally 20-25 average channel widths in length. Within each of the study reaches, areas of sediment deposition (*e.g.,* sediment wedges), large woody debris (LWD), stream banks, and other notable features (*e.g.,* valley bottom and active channel margins, wetted perimeter) are mapped by using a modified version of the rod and tape mapping technique described in detail by Platts et. al. (1987). A metric measuring tape is stretched down the stream channel, beginning at either the bottom or top of the reach. The length and bearing to the first turning point is noted. The tape is secured with rebar stakes. A survey rod is held perpendicular to the tape, and the distance of significant features from the fixed tape is noted, as the map is drawn to scale using "rite-in-the-rain" graph paper. Measurement intervals are spaced along the tape as needed to sketch important features. Stream gradient between the ends of the tape is measured using a hand level and survey rod.

2. After the sketch is made, each sediment wedge feature is numbered. All sediment wedges within the reach are generally measured. If it is not feasible to conduct a complete sample, a minimum of 10 sediment wedges are measured. If sub-sampling is to be used, the depositional units to be sampled are selected by random numbers.

3. Sediment wedges are measured for volume calculations using a metric carpenter's tape, a level rod, and a hand level. Volume of the sediment deposit (assumed to be wedge-shaped) is calculated as: *Average Width * Length * ½ Height*. The width of the sediment wedge is

calculated by averaging three readings taken at 25%, 50%, and 75% of the total length. The length is measured along the longest axis of the deposit, and the axis measured is indicated on the sketch map. The height of the sediment wedge is defined as the difference between a level rod reading taken on the streambed at the downstream side of the obstruction forming the deposit, and a rod reading taken on the surface of the sediment deposit immediately upstream of the obstruction. The type of retention structure is noted, such as LWD, boulder/cobble cluster, rootwad, or a combination of these elements.

4. Follow-up surveys are made as described in steps 1, 2, and 3 using an updated sketch map. A copy of the original sketch map is used as a template for the updated map. New or substantially modified sediment deposits and storage elements are surveyed and added to the sketch map, and highlighted as new or modified features. Features which are no longer present are highlighted on the copy of the original sketch map. Following the procedures outlined above, the same numbered features that were initially measured are re-surveyed. Any new sediment deposits that have been added to the sketch map are also numbered and surveyed. Follow-up surveys are conducted at similar flow regimes as the initial survey, at intervals of approximately one year, although they may be done more frequently following major hydrologic or geomorphologic events.

BMP Effectiveness Rating:

Determination of BMP effectiveness considers the type, magnitude and rate of change in sediment deposits and storage elements in the treatment reach relative to that in the control reach.

The BMP is considered effective if there is not evidence of an increase in sediment deposition, loss of sediment storage function, or streambed destabilization, as reflected in changes in sediment storage elements and sediment deposits, that is attributable to forest practice activities.

References:

Megahan, W.F. 1982. "Channel Sediment Storage Behind Obstructions in Forested Drainage Basins Draining the Granitic Bedrock of the Idaho Batholith." **In** Sediment Budgets and Routing in Forested Drainage Basins 1982. Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-141

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for Evaluating Riparian Habitats With Applications to Management. U.S. Dept. of Agriculture, U.S. Forest Service, Intermountain Research Station, General Technical Report INT-221.

Streambed Stability Survey

Site ID # ____________________

Site Name ____________________

Date ____________ Surveyors ____________

Survey # ____________ Flow ____________

Weather ____________ Reach # ____________

Comments:

Sediment Deposit #	Deposit Length	Deposit Width 25%	50%	75%	Ave.	Deposit Height Top Elev.	Base Elev.	Ht. Top-Base

"Rite in the Rain" ALL-WEATHER WRITING PAPER J. L. DARLING CORP TACOMA, WA 98421

No. 352

Channel Substrate Transects

Purpose:

To measure and evaluate characteristics of streambed substrates, including particle size distribution, substrate stability/mobility, the extent of surface fines, and interstitial space habitat, within depositional areas of treatment and control stream reaches, and to evaluate changes in streambed substrates over time.

Materials:

hand compass
metric carpenter's tape
interconnected series of 30 cm. diameter hoops
particle size class samples encased in resin and/or a metric ruler or calipers
hinged plexiglass scale
substrate viewer (*e.g.,* viewing tube with plexiglass lens)
30 and 100 meter measuring tapes
7 meter telescoping level rod
hand level
"rite-in-the-rain" field forms and clipboard
"rite-in-the-rain" graph paper (5 squares to the cm.)
pencils
random number generator
5/8 inch re-bar stakes
cross-section kit (tension clamps, etc.)
survey flagging

Site Selection Criteria:

Study reaches are selected at timber harvest or road construction sites, including sites where RMZs or RLTAs are left as a water quality protection measure, where initial surveys can be conducted prior to in-stream impacts from the forest practice under evaluation. A control reach is generally located immediately upstream of the treatment reach. This survey technique is most appropriate for stream reaches with gradients less than 8% that have a riffle-pool, plane bed, or low gradient step-pool channel morphology.

Method Summary:

Detailed sketch maps of study reaches are made using the rod and tape technique. All major stream channel features are plan-view mapped, and areas of sediment deposition (*e.g.,* gravel bars, low gradient riffles, sediment wedges, pools) are identified throughout the reach. Transects are established within non-pool depositional areas of control and treatment reaches to evaluate streambed substrate characteristics, including particle size distribution, extent of surface fines, cobble embeddedness/interstitial space index, and cross-section profiles. As an option, fine sediment deposition in pools may also be monitored using the residual pool depth sampling technique. Surveys are conducted during low flow conditions. The initial surveys are conducted prior to any in-stream impacts from the forest practices under evaluation. Follow-up surveys are conducted over a one to three year period following the forest practice operations to evaluate changes in depositional substrates and streambed stability.

Assumptions:

Changes in substrate composition and accumulations of fine sediment within depositional areas of stream channels can be measured by sequential surveys of these depositional areas.

The magnitude, rate, and type of change in channel substrates observed in representative control reaches represents a baseline condition against which changes in treatment reaches can be compared, and certain differences may be attributed to the effects of forest practices.

Sediment-producing activities that result in the filling of interstitial space habitat with fine sediment adversely impact aquatic life habitat and beneficial uses of the stream.

Survey Method:

1. The survey is conducted during low flow conditions. Study reaches are 20-25 active channel widths in length. Within study reaches, riffles, gravel bars, sediment wedges, large woody debris (LWD), pools, stream banks, and other notable features (*e.g.,* active channel margins, wetted perimeter) are mapped by using a modified version of the rod and tape mapping technique described in detail by Platts et. al. (1987). A metric measuring tape is stretched down the stream channel beginning at either the bottom or top of the reach. The length and bearing to the first turning point is noted. The tape is secured with rebar stakes. A survey rod is held perpendicular to the tape, and the distance of significant features from the fixed tape is noted, as the map is drawn to scale using "rite-in-the-rain" graph paper. Measurement intervals are spaced along the tape as needed to sketch important features such as stream banks, LWD, and the outlines of pools, bars, and other sediment deposition areas. Stream gradient between the ends of the tape is measured using a hand level and survey rod.

2. After the sketch is made, depositional areas are numbered. For purposes of this survey, depositional areas include low-gradient riffles, gravel bars, and sediment wedges. Pools are also identified and numbered on the sketch. If it is not feasible to sample all depositional areas

due to the large number of individual depositional units in the reach, a minimum of 10 depositional units are sampled. If sub-sampling is used, the depositional areas to be sampled are selected by random numbers. All depositional units are sampled if there are less than 10 within a reach.

3. Transects are established at the midpoint of each depositional unit. For depositional units greater than 5 meters in length, at least two transects are established at 25% and 75% of the total length. If more than two transects are placed within a depositional unit (*e.g.,* a long, low-gradient riffle), they are evenly spaced between the upper and lower ends of the depositional unit. If there are less than 10 depositional units within a study reach, distribute at least 10 transects among the depositional areas present. A series of 30 cm. diameter hoops is placed starting at the left bank (facing downstream) ordinary high water mark, and numbered 1-n depending on how many hoops are required to reach the right bank. At each transect, the following information is recorded on the field form:

a. Dominant and sub-dominant particle size are visually classified within each hoop using the particle size classification described in Table 1.

Table 1. Particle size classes.

CLASS NAME	CLASS SIZE (mm.)
sand & smaller	< 2
fine gravel	2 - 6
gravel	6 - 64
cobble	64 - 256
small boulder	256 - 512
large boulder	> 512

b. The percent surface fines—(particles less than 6.0 mm.), within each hoop are visually estimated to the nearest 10 % (*e.g.*, 0-10, 11-20, etc.), and recorded on the field form.

c. For each transect, a random number is generated to select a hoop for a cobble embeddedness sample. The hoop number sampled is recorded and the percent embedded is determined for all particles between 64 and 256 mm. median axis diameter. With the thumb and forefinger defining the plane of embeddedness, the total depth and embedded depth (see Figure 1) are measured using a hinged plexiglass scale. The percent embedded is recorded on the field form and particle set aside. Cobbles are replaced after the sampling is complete. The number of free matrix particles (% embeddedness equals zero) are counted and their total depth measured. The percent free matrix particles (as a proportion of the total number of particles in the measured size range) is calculated. (Note: If a consistent relationship can be established between % free matrix and % embeddedness, then a possible option for future surveys may be to only measure % free matrix and use this as a surrogate for % embeddedness, as suggested in MacDonald *et al.* (1992)).

Three options that are available for data analysis are briefly outlined below. These options are described in more detail in Burton and Harvey (1990). Cobble embeddedness data gathered through this method can be applied to all three options.

1. The formula described in Figure 1 for measuring Percent Embeddedness.

2. Weighted embeddedness (WE) is an analysis method used for hoops with >10% of the surface substrate covered by fines (see Figure 2). For the purposes of this study, fines are defined as particles less than 6.0 mm.

WE = Proportion of Surface Fines * 100 + (1 - Proportion of Surface Fines) * ME

Where ME (measured embeddedness) is equal to Percent Embeddedness from Figure 1.

3. The third analysis method, Interstitial Space Index (ISI), reflects the amount of interstitial space habitat available for use by aquatic organisms.

ISI = Σ (D1 - D2)/ Hoop Area (square meters)

Where D1 and D2 are as shown in Figure 1.

d. Lastly, a pebble count is conducted. At each transect, 10 particles are randomly selected by moving along the transect line and, without looking, picking up the particle first touched by the index finger. The particles are measured along the median axis using a metric ruler or calipers, and the information recorded. A total of at least 100 particles are measured for each reach. From this pebble count data, the dominant and sub-dominant particle size classes for the overall reach are determined.

4. Selected cross-section profiles are surveyed to monitor changes in relative bed elevations and channel form. The cross-section locations are marked with permanent re-bar stakes driven into the stream bank . Cross-section profiles are surveyed by securing a 30 meter measuring tape at consistent tension across the stream to each permanent stake. The height from the tape to the surface cross-section feature is measured using a metric surveyor's rod. Alternatively, differential leveling may be performed using a hand level and survey rod. Measurements are made at frequent intervals along the tape, as needed to document the shape of stream banks and changes in streambed elevation. Cross-section profiles are then plotted to scale.

5. As an optional addition to this survey, fine sediment deposition in pools may be monitored by measuring residual pool depth. Residual pool depth is defined as the depth of water remaining within the pool if stream flow were reduced to zero. Residual pool depth is measured by taking the depth of the pool at it's deepest point and subtracting the depth of water at the riffle crest, as described in Lisle (1987). The riffle crest is that area of the stream where the pool "empties" downstream. Pool depth and the depth of fines on pool substrates may also be measured in a grid pattern to provide more detailed information on pool filling and fine sediment deposition.

6. Follow-up surveys are conducted using the same techniques described above. A copy of the original sketch map is updated to map changes in sediment deposition and streambed features, including any new features. For measurements of embeddedness during follow-up surveys, the hoop is located immediately upstream of the hoop that was originally sampled. Transects and cross-sections are generally re-surveyed annually at similar flow regimes, though they may be done more frequently following major hydrologic events.

BMP Effectiveness Rating:

BMP effectiveness is evaluated in terms of the magnitude, rate, and type of change documented in depositional areas of the treatment reach relative to changes in the control reach.

The BMP is considered effective if there is no evidence of an increase in deposition of fine sediment or loss of interstitial space habitat that is attributable to forest practice activities.

References:

Burton, T.A. and G.W. Edwards. 1990. Estimating Intergravel Salmonid Living Space Using the Cobble Embeddedness Sampling Procedure. Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau, Boise, ID. Water Quality Monitoring Protocols--Report No. 2.

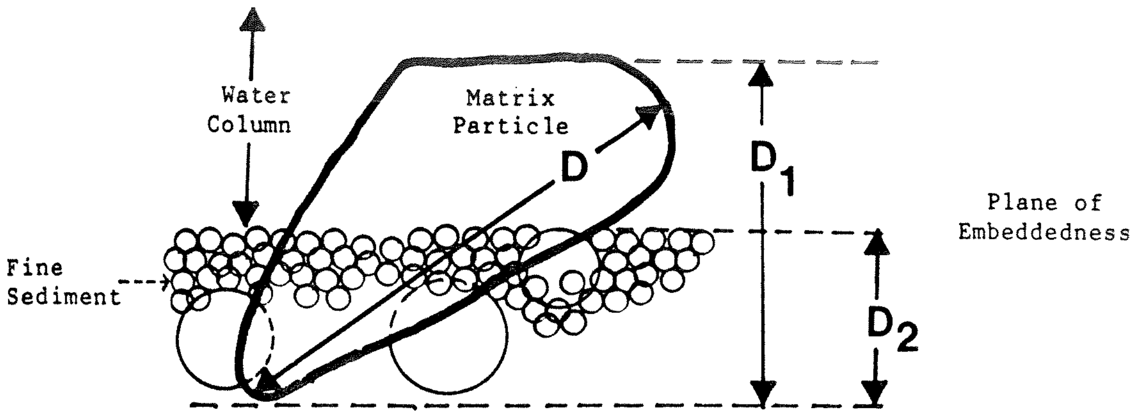
Lisle, T.E. 1987. Using "Residual Depths" to Monitor Pool Depths Independently of Discharge. U.S. Dept. of Agriculture, U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Note PSW-394.

MacDonald, L.H., A.W. Smart, R.C. Wissmar, 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for Evaluating Riparian Habitats With Applications to Management. U.S. Dept. of Agriculture, U.S. Forest Service, Intermountain Research Station, General Technical Report INT-221.

Torquemada, R.J., W.S. Platts. 1988. "A Comparison of Sediment Monitoring Techniques of Potential Use in Sediment/Fish Population Relationships." **In** Idaho Habitat Evaluation for Off-site Mitigation Record, Annual Report 1987. Idaho Department of Fish and Game, and Bonneville Power Administration. Boise, Idaho.

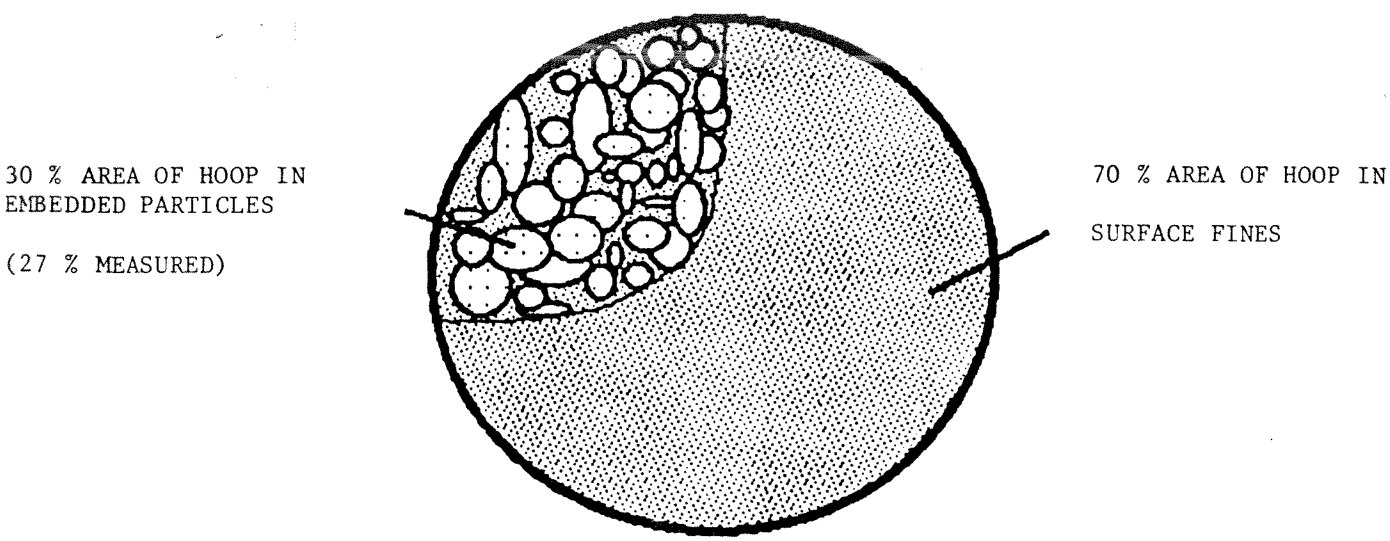
Figure 1. Measurement to determine particle embeddedness for cobble and random hoop techniques (from Torquemada and Platts, 1988).



$$\text{Percent embeddedness for each rock} = \left(\frac{D_2}{D_1}\right) \times 100.$$

Mean embeddedness = Sum of all individual percentages divided by number of rocks.

Figure 2. Weighted Embeddedness Calculation (from Torquemada and Platts, 1988).



WEIGHTED EMBEDDEDNESS = (PROPORTION OF SURFACE FINES) * 100 +

(1 - PROPORTION OF SURFACE FINES) * MEASURED EMBEDDEDNESS

EXAMPLE: (.70 * 100) + (.30 * 27) = 78 %.

DOMINANT/SUB-DOMINANT AND % FINES FIELD FORM

Site Id # ______________ Site Name ________________ Reach Number ________________

Transect # ______________ Distance of Transect from Top of Reach (meters) __________

______________ __________

______________ __________

______________ __________

Survey # ______________ Weather ________________ Flow ________________

TRANSECT #		TRANSECT #		TRANSECT #		TRANSECT #	
% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.

HOOP #

"FINES" ARE LESS THAN 6.0 mm.

CLASS NAME	CLASS SIZE (mm.)
sand & smaller	< 2.0
fine gravel	2.0-6.0
gravel	6.0-64.0
cobble	64.0-256.0
small boulder	256.0-512.0
large boulder	>512.0

PEBBLE COUNT FIELD FORM

Site Id # ______ Site Name ______ Reach Number ______

Surveyors ______ Date ______

Transect # ______ Survey # ______ Weather ______ Flow ______

Comments ______

______

______

______

CLASS NAME	CLASS SIZE (mm.)	PARTICLE COUNT	TOTAL # PARTICLES	% TOTAL	% CUMULATIVE
Sand & Smaller	Less Than 2.0				
Fine Gravel	2.0 - 6.0				
Gravel	6.0 - 64.0				
Cobble	64.0 - 256.0				
Small Boulder	256.0 - 512.0				
Large Boulder	Greater Than 512.0				

COBBLE EMBEDDEDNESS FIELD FORM

Site Name ______________________ Site Id # ______ ______________

Date ______________ Surveyors ____________________________

Reach Id # __________ Transect # ______ Total # Cobbles Measured ____

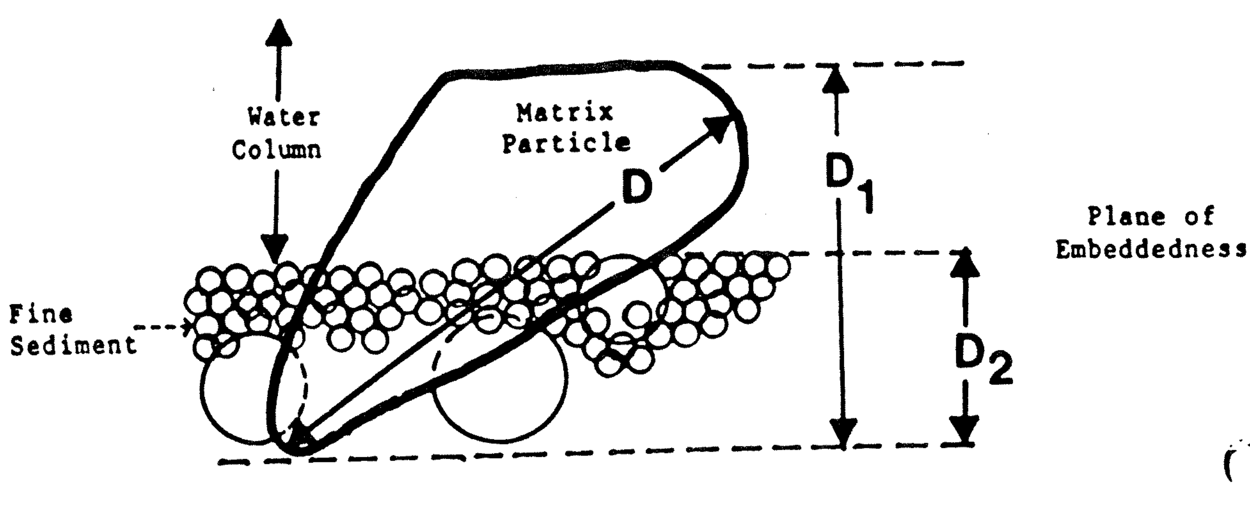
Hoop # __________ Cobbles To Be Measured Are Between 6.4 and 25.6 cms.

Comments ____

____

Survey # ________ Weather ______________ Flow ______________

Cobble #	d (cms.)	d1 (cms.)	d2 (cms.)	Cobble #	d (cms.)	d1 (cms.)	d2 (cms.)



Amphibian Survey

Purpose:

To assess stream amphibian communities and habitats that may be affected by forest practices, and evaluate changes in amphibian communities and habitats over time in treatment and control streams.

Materials:

30 and 100 meter measuring tapes
dip nets
plastic bags and plastic buckets
flagging
field book, data sheets, and pencils
dip nets
hardware cloth screen
metric rulers
clinometer
thermometer

Site Selection Criteria:

Sites for conducting amphibian surveys are first through third order, perennial streams within timber harvest units, including those where RMZs or RLTAs are established as a water quality protection measure. Off-site control streams are established in similar habitats in the general vicinity.

Method Summary:

Sampling procedures adapted from those described by Bury and Corn (1991) are employed in western Washington to characterize amphibian communities and habitats in treatment and control streams. These procedures involve selection of three ten meter sampling reaches in each stream, characterizing the habitat of the reach, conducting hand searches to capture all stream amphibians within the reach, and describing the animals captured and microhabitat for each capture. Sampling is conducted on both treatment and control streams before and after forest practice operations. Stream amphibian sampling in western Washington is conducted by investigators from the University of Washington as a part of forest practices research projects, including the CMER Wildlife RMZ study. Because of differences in the life histories of eastern Washington amphibians, an alternate method using time-constrained searches of aquatic and riparian habitats and pitfall trapping is used to sample amphibian communities (O'Connell and Hallett, 1992). Amphibian sampling in eastern Washington is conducted by investigators from Eastern Washington University and Washington State University as part of the CMER Wildlife-RMZ research project. For the water quality sediment study, we have co-located our BMP effectiveness study sites at stream amphibian study locations to obtain information on the effects of forest practices on biological communities for use in conjunction with other survey results.

Assumptions:

The characteristics of and changes in stream amphibian communities in control streams represents a baseline condition against which changes in amphibian communities in treatment streams can be compared, and certain differences in the response of stream amphibian communities may be attributed to the effects of forest practice activities that alter stream habitat.

Stream amphibians are dependent on certain habitat elements, including stable stream banks, interstitial space habitat and cover, and other aquatic habitat conditions, and their response to forest practices is an indicator of BMP effectiveness.

Survey Method:

Detailed sampling methods are described in Bury and Corn (1991), Kelsey (1995) and O'Connell and Hallett (1992).

BMP Effectiveness Rating:

Determination of BMP effectiveness considers changes in amphibian communities and habitats in treatment streams relative to that in control streams. The BMP is considered effective if there is no evidence of reduced diversity and/or measures of relative abundance in amphibian communities associated with aquatic habitat degradation or direct effects of forest practices on stream amphibians.

(Note: This survey technique was not used to make BMP effectiveness calls within the weight-of-evidence/case study framework, because the study design employed by cooperating researchers was not intended for case studies. Preliminary results from stream amphibian surveys are discussed in the *Biological Assessments* section of the report.)

References:

Bury, R.B. and P.S. Corn. 1991. Sampling Methods for Amphibians in Streams in the Pacific Northwest. General Technical Report PNW-GTR-275. USDA Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Kelsey, K.A. 1995. Responses of Headwater Stream Amphibians to Forest Practices in Western Washington. PhD Dissertation, University of Washington, Seattle, Washington.

O'Connell, M.A. and J.T. Hallett. 1992. Sampling Methods for Amphibians and Reptiles in the Forests of Northeast Washington - Riparian Management Zone Study. Appendix I of Eastside RMZ Study June 1992 Progress Report to TFW Wildlife Steering Committee. Eastern Washington University, Cheney, Washington.

Macroinvertebrate Survey

Purpose:

To evaluate characteristics of stream macroinvertebrate communities and habitats that may be affected by forest practices, and document changes in macroinvertebrate communities over time in treatment and control streams.

Materials:

30 and 100 meter measuring tapes
0.3 m^2 (D-frame) and 1 m^2 kick nets
dip nets
plastic bags and other sample containers
sample preservatives
field sorting trays
flagging
field book, data sheets, and pencils

Site Selection Criteria:

Sites for conducting macroinvertebrate surveys are harvest units or road construction sites with first through third order streams. If suitable control reaches cannot be located upstream of the forest practice operation, off-site control streams in the general vicinity may be used.

Method Summary:

Sampling and analytical procedures described in EPA (1992) and Plotnikoff (1994) are employed to characterize macroinvertebrate communities and habitats in study stream reaches. An upstream/downstream or paired stream sampling design is employed to compare treatment and control reaches. Sampling procedures involve selection of at least two transects within each study reach, with one kick sample from each of the predominant habitat types (*e.g.*, riffles, pools, etc.) composited at each transect. As an option, especially if the study reach is dominated by only one habitat type (*e.g.*, riffles), discrete samples collected from different locations within the reach may be analyzed without compositing. In small streams with limited or very discrete macroinvertebrate habitat zones, four kick samples may be collected from different locations for compositing. Additional discrete samples may be collected for assessment of variability. Habitat for the study reaches is evaluated according to the habitat assessment protocol developed for bioassessment in the Pacific Northwest (EPA, 1992). Sampling is conducted on both treatment and control streams before and after forest practice operations. Macroinvertebrate sampling is conducted primarily by cooperators within the Department of Ecology as a part of ongoing bioassessment activities. Certain BMP effectiveness study sites are co-located with macroinvertebrate sampling locations to obtain information on the effects of forest practices on biological communities for use in conjunction with other survey results.

Assumptions:

The characteristics of and changes in stream macroinvertebrate communities in control streams represents a baseline condition against which changes in macroinvertebrate communities in treatment streams can be compared, and certain differences in the response of macroinvertebrate communities may be attributed to the effects of forest practice activities that alter stream habitat.

Stream macroinvertebrates are dependent on certain habitat elements, including interstitial space habitat, naturally-occurring sediment and hydrologic regimes, and other aquatic habitat conditions.

Survey Method:

Detailed sampling methods are described in Plotnikoff (1994) and EPA (1992).

BMP Effectiveness Rating:

Determination of BMP effectiveness considers the type of changes in macroinvertebrate communities and habitats in treatment streams relative to that in control streams. The BMP is considered effective if there is no evidence of adverse changes, as measured by various biometrics, associated with habitat degradation or other effects of the forest practice. Adverse changes could include reduced species diversity, or adverse changes in the functional attributes of macroinvertebrate communities.

References:

Environmental Protection Agency. 1992. Draft Region 10 In-Stream Biological Monitoring Handbook for Wadable Streams in the Pacific Northwest. G. A. Hayslip, ed. EPA 910/9-92-013. U.S. Environmental Protection Agency, Region 10. Seattle, Washington.

Plotnikoff, R.W. 1994. In-Stream Biological Assessment Monitoring Protocols: Benthic Macroinvertebrates. Publication #94-113, Washington State Department of Ecology, Olympia, Washington. 27 pp.

Runoff Sampling

Purpose:

To assess fine sediment loads and effects in streams due to erosion of road surfaces and other disturbed areas where forest practices have occurred near streams.

Materials:

100 and 30 meter measuring tapes
survey flags
field book
runoff sampling field forms
channel condition survey field forms
lead pencils
Model DH-81/D-77 and DH-48 Suspended Sediment Samplers
1000 and 500 ml plastic sample bottles
ice chest with ice and packaging materials
wristwatch and stopwatch
tipping bucket rain gage and pre-programmed datalogger
topographic map of the location
bucket of known volume
flexible flume for ditch flow measurement
Marsh McBirney flow meter
capacitive depth probe and pre-programmed datalogger, or staff gage
manual traffic counters

Site Selection Criteria:

Sites for runoff sampling are selected at locations where main haul roads, newly constructed roads, or skid trails cross streams in such a manner that a control reach can be located immediately upstream of the crossing and/or harvest unit.

Method Summary:

Water samples are collected during runoff events and analyzed for turbidity and total suspended solids to assess fine sediment loading from road or skid trail crossings of streams. Samples are collected at multiple sampling stations in the stream above and below the road or skid trail crossings, as well as from road ditches. Ancillary information collected during the sampling period includes rainfall amount and intensity, streamflow, stream channel conditions, and vehicle traffic.

Assumptions:

Turbidity and suspended sediment measured at sampling stations immediately upstream of forest practice operations establish the background conditions against which the localized effects of the forest practice, including fine sediment loading to the stream, can be compared.

Survey Method:

1. Upon arrival at the site, the recording tipping bucket rain gage is set up in the vicinity, at a location free from overhead obstructions such as forest canopy. The datalogger should be pre-programmed to record tips at 15 minute intervals. The stage height recorder (referred to in step 6) is also installed upon arrival at the site.

2. The following survey and site information is recorded on the front page of the field form:

Study Site ID (*e.g.,* S-01)
Survey ID (*e.g.,* RO01)
Name of Road or Unit
Date and Time
Surveyors
Length of contributing road segment or skid trail
Gradient of road or skid trail contributing segment
Road or skid trail design info (inslope/outslope; ditches; waterbars; surface; etc.)
Type of crossing (culvert; bridge; ford; etc.)
Hillslope gradient in vicinity of crossing

3. Five to six runoff sampling stations are established as follows:
   - 2 background stations are established upstream of the road/skid trail crossings, or upstream of the harvest unit, spaced no more than 5 channel widths apart; Upstream sampling stations are located as close as practicable to the effects being evaluated.
   - 2 stations are established downstream of the road/skid trail crossing (below the immediate mixing area of the crossing site), spaced no more than 5 channel widths apart;
   - 1 station is established in the stream in the immediate vicinity of where the drainage discharge enters the stream, such as a ditch outflow (*i.e.,* the mixing area); and, for roads or skid trails with ditches draining to stream, 1 station is established to sample the ditch flow immediately upstream of the ditch outfall;

Stations are marked with survey flags. A sketch of the study site is made in the field book. The sketch shows the general configuration of the stream and contributing road or skid trail segments, noting the locations of sampling stations. Where feasible, sampling stations are established and flagged during site reconnaissance. On a day prior to sampling or following the completion of runoff sampling, stream distance from the crossings to sampling stations are measured by tape and noted on the sketch. Any other significant local erosional features are noted on the sketch.

4. The sampling schedule is established, indicating times to start each sampling sequence. Each station should be sampled two to four times, spaced at approximately two hour intervals, or at more frequent intervals if feasible.

5. The first samples are collected according to the established schedule, in a sequence that begins with the station farthest downstream and working upstream so as not to disturb upstream areas prior to sampling. At each stream station, a depth-integrated sample is collected from the thalweg using the Model DH-81/D-77 or DH-48 Suspended Sediment Sampler (detailed sample collection methods are described in Guy and Norman, 1970). Sample size required is generally 1000 to 1500 ml depending on the turbidity level (the greater the turbidity, the less volume required). The sampler is lowered to the stream bottom and raised at a constant rate. For sampling ditches, samples are hand collected in plastic bottles by dipping directly in ditch flow, taking care not to disturb the bottom of ditch. In the case of very shallow streams, all samples may be collected by hand dipping. In addition to these samples, two field replicate samples are collected during the sampling period. These replicates are samples collected at the same time and place as another sample, and are given unique sample ID numbers and submitted to the laboratory as "blind" replicates (*i.e.,* the lab doesn't know they are replicates). They facilitate an evaluation of field and laboratory precision. (In addition, the laboratory runs duplicate analyses as a part of their internal quality control practice.) All samples are stored in ice and delivered to Ecology's Manchester Laboratory within 48 hours of collection for total suspended solids and turbidity analysis.

6. Streamflow is gaged once or twice during the sampling period at one upstream and one downstream station, and, if present, the ditch discharge is gaged as well. The first gaging is generally done after the initial sampling sequence, and the second is done at the conclusion of sampling. Stream cross-sections with relatively uniform flow are gaged using a Marsh McBirney flowmeter to take measurements of velocity at multiple points along the cross-section, with cross-sectional area measured by wading rod and tape. At ditch outfalls, discharge is measured by a stopwatch and bucket technique: the entire discharge is directed into a bucket of known volume and the time required to fill the bucket is determined with a stopwatch. This is repeated three times and the average discharge is recorded. Where necessary, a flexible flume may be used to capture and direct the ditch flow into the bucket.

In order to record a more complete record of streamflow during the sampling period (to facilitate a better determination of whether samples were collected on the rising or falling limb of the hydrograph), a capacitive depth probe stage height recorder is installed in the stream at the downstream streamflow gaging location, with the datalogger programmed to record stage height at 15 minute intervals. Alternatively, a staff gage may be temporarily installed and stage heights recorded manually in the field notes throughout the sampling period.

7. For road crossing sites, vehicle traffic during the sampling period is counted using two hand-held counters; one for log trucks and other heavy vehicles and one for light vehicles. The counts are maintained throughout the day. If a vehicle passes at, or within one minute of, the time of sample collection for the ditch or ditch outflow sampling station, the time the vehicle passes is noted in the "Comments" column of the field form.

8. Upstream and downstream study reaches are surveyed to evaluate potential in-stream sources of suspended sediment (*e.g.,* actively eroding banks) between upstream and downstream study sites. The Channel Condition Survey technique and field form is used for this evaluation, which should be done at the conclusion of runoff sampling (so as not to disturb sediments by walking the reaches during the sampling period), if it has not been done on a prior site visit.

BMP Effectiveness Rating:

Determination of BMP effectiveness is based on comparisons of downstream turbidity and total suspended solids concentrations to local background conditions, as reflected in the results from the upstream sampling sites.

The BMP is considered effective if there are no violations of the numeric water quality standards for turbidity or potentially adverse increases in total suspended solids associated with road drainage during runoff events. Evaluation of impairment due to suspended sediment considers potential direct effects on aquatic life due to high water concentrations (based on published effects data). Siltation effects on downstream habitats from fine sediment loading may also be considered.

References:

Guy, H.P. and V.W. Norman. 1970. Field Measurements for Measurement of Fluvial Sediment. Techniques of Water Resources Investigation, Book 3, Chapter C2. United States Geological Survey. Washington D.C.

Runoff Sampling Field Form

Study Site ID #: ____________ Date: ____________

Road or Unit Name: ____________

Survey ID#: RO- ____________

Length of Contributing Road or Skid Trail Segment:

Road or Skid Trail Design Info: ____________

Construction Technique: ____________

Drainage Control: ____________

Surfacing: ____________

Hillslope Gradient (%): ____________

Road/Skid Trail Gradient (%): ____________

Datalogger Scheme for Raingage: ____________

Datalogger Scheme for Stage Height: ____________

Other Comments:

Traffic Count: <u>Heavy Trucks</u> <u>Light Vehicles</u>

Sketch of Study Site:

Site ID#: ______________ Survey ID#: RO-______________

"Rite in the Rain" ALL WEATHER WRITING PAPER

J. L. DARLING CORP TACOMA, WA 98421

No. 352

Run-Off Sampling Field Form

Study Site ID # ______________ Date ______________

Surveyors ______________

Sampling Station Number	Field Bottle ID #	ManLab ID #	Time Sample Collected	Comments:

Appendix J

Case Study Summaries

Appendix J: List of Case Study Summaries in the Order Presented

Olympic Physiographic Region
O-01: Salmon Creek
O-02: Walker Pass
O-03: Jupiter Road
O-04: 9000 Mainline
O-05: Gunderson Creek
O-06: Whale
O-07: Gunderson 2

Willapa Hills Physiographic Region
W-01: Sears Creek
W-02: Neiman Creek
W-03: Train Whistle
W-04: 1600 Mainline
W-05: Bus Stop
W-06: Pot Pourri
W-07: Night Dancer

Southern Cascades Physiographic Region
S-01: Camp One Road
S-02: 8 Road Unit 2
S-03: Ohop Blowdown
S-04: Friday Creek II
S-05: Sundog
S-06: Big Wedge
S-07: Eleven 32
S-08: Kapowsin
S-09: Simmons Creek

Northern Cascades Physiographic Region
N-01: Upper Shop
N-02: Pilchuck Mainline

Eastern Cascades Physiographic Region
E-01: Fish Lake Mine
E-02: Plesha Road
E-04: Green Canyon
E-05: Aspen Patch

Northern Rockies Physiographic Region
R-02: Muddy West
R-03: Muddy East
R-04: Buck East
R-05: Buck West
R-06: Middle
R-07: Sherry Creek

APPENDIX J: CASE STUDY SUMMARIES

Appendix J contains case summaries for each study site, that include: narrative descriptions of the study sites; site maps showing locations of streams, forest practice operations, and BMP effectiveness surveys; weight-of evidence summaries with effectiveness ratings for the BMPs evaluated at the site; and survey results summaries for individual surveys conducted at the site. Additional site-specific data from BMP effectiveness survey results are contained in Appendix C (sediment routing surveys), Appendix D (channel condition surveys), Appendix E (stream bank erosion surveys), Appendix F (stream crossing culvert surveys), Appendix G (relief culvert surveys), and Appendix H (cutbank/fillslope surveys).

Notes on Information Sources for Narrative Study Site Descriptions:
The narrative study site descriptions provide general information on each study site. Included in these descriptions is information on the geologic setting of each site. The sources 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, cutbank/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 identified by listing the soil series followed by slope phases. Harvest and road construction BMP slope hazard categories given in the descriptions are based on field measurements of stream valley and hill slope gradients in the vicinity of BMP effectiveness surveys, and the slope 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 usually noted in the descriptions. Stream channel morphology classifications are based on field observations, with study reaches classified according to the scheme of Montgomery and Buffington (1993). Valley form is based on the simplified scheme used in the channel condition survey method. Average channel gradients are based on weighted averages of clinometer readings taken throughout study reaches, as described in the channel condition survey method. Any references to the left or right side of a stream 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. Where the width of stream buffers (RMZs or RLTAs) are given, these refer to the average, one-sided buffer width in the vicinity of specific survey areas, as measured from low-altitude aerial photos taken for evaluation of harvest practices. Dates of forest practice operations were supplied by landowner representatives or are based on field observations. Survey techniques referred to in the site narratives are as described in Appendix I unless otherwise noted.

Notes on study site maps: Study site maps were produced by Randy Coots of the Watershed Ecology Section using Arc-Info and ArcView 2 GIS software with available GIS map coverages and a digital elevation model. Hydrography and water types within study areas have been ground-truthed where water types are given.

Olympic Physiographic Region

Site O-01: Salmon Creek

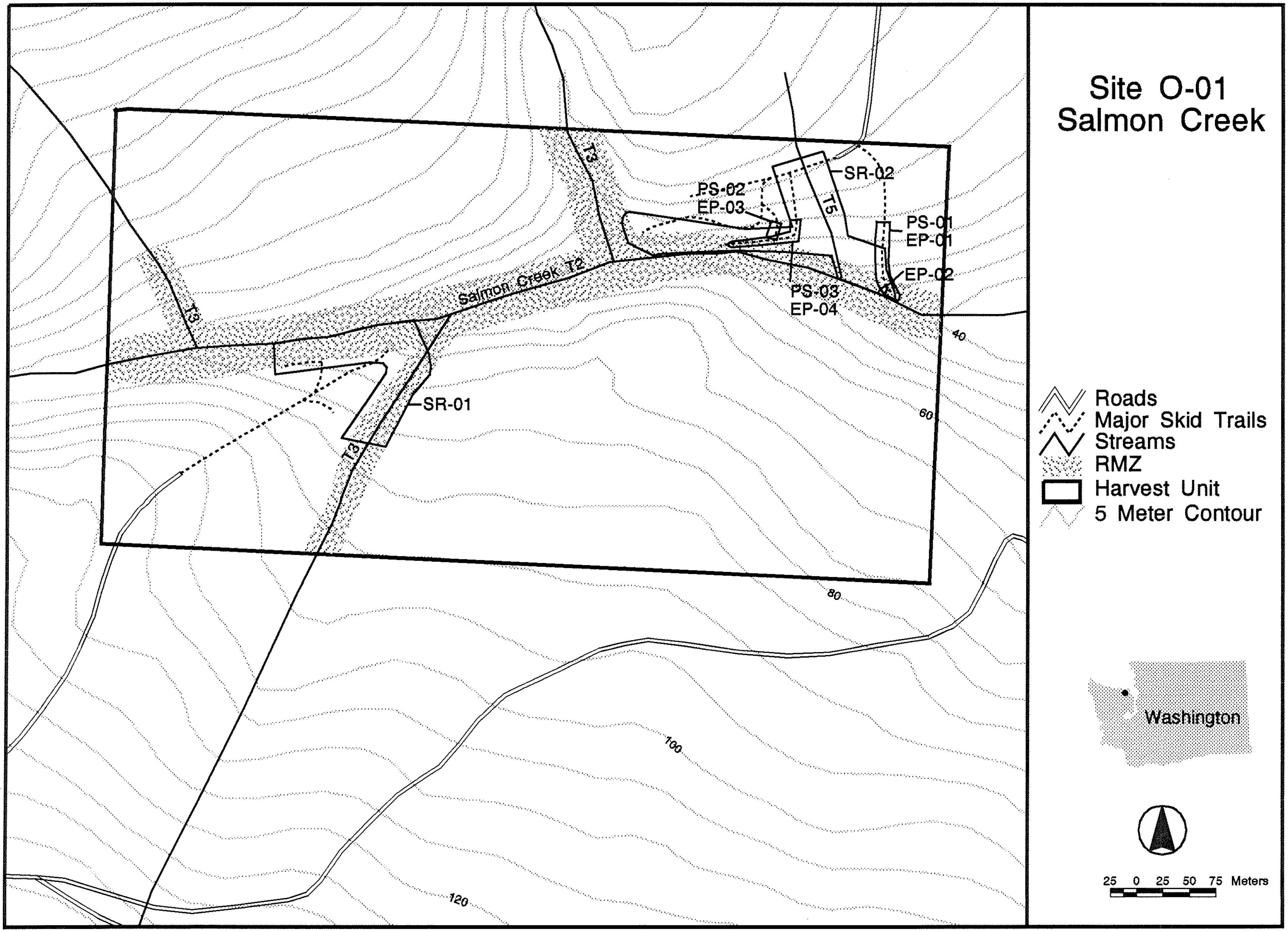
The Salmon Creek site is a harvest practice located in the western portion of Jefferson County in the Olympic physiographic region. The underlying geology is glacial deposits with areas of basalt and mudflow breccia. Soils are mapped as Alderwood gravelly sandy loam with two phases, 0-15% slopes along the left bank tributaries to Salmon Creek, and 30-50% slopes along Salmon Creek itself. Soils on the right side of Salmon Creek are Alderwood gravelly loam, 0-15% slopes. The disturbed soil slope stability rating for the 0-15% 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 0-15% 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 that is a major tributary to Discovery Bay on the Strait of Juan De Fuca. There are three left bank tributaries to Salmon Creek within the northern part of the harvest unit. The tributary along the western boundary of the unit is a zero order Type 3 stream, 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 stream that is not depicted on DNR water type maps. Along the right bank of Salmon Creek is one 2nd order Type 3 tributary that enters Salmon Creek in the center of the harvest unit. The FPA also showed a Type 4 tributary to this Type 3 stream traversing the southern part of the harvest area, but ground-truthing of the topographic swale revealed that this stream did not actually exist.

Forest practices conducted at the site include a 21 hectare clearcut harvest using ground-based yarding methods. A Riparian Management Zone (RMZ) was established along the Type 2 and 3 streams. Selective logging occurred within the inner gorges in some areas of the RMZ. The width of the RMZ averaged 43 meters and 66 meters in two survey areas along Salmon Creek, and 10 meters along the Type 3 tributary in the southern part of the harvest unit. Portions of the unit were harvested by feller-buncher equipment. Harvest was completed by September of 1992.

The BMPs evaluated at this site were the RMZs along Salmon Creek and one of the Type 3 tributaries with adjacent ground-based harvesting, as well as ground-based harvesting in the vicinity of the Type 5 stream without stream buffers. Surveys employed to evaluate BMP effectiveness included sediment routing surveys conducted in two different sections of the harvest unit in February and August of 1993, with follow-up surveys in May and October of 1994. One of the sediment routing survey areas covered part of the Type 3 RMZ and a portion of the RMZ along the south side of Salmon Creek. The other sediment routing survey area covered a portion of the RMZ along the north side of Salmon Creek, and an adjacent harvest area in the vicinity of the un-buffered Type 5 stream. Erosion and sediment delivery associated with selected skid trails was further evaluated using three photo-point surveys and four erosion pin networks, surveyed in November 1992 and March 1994.

Site O-01
Salmon Creek



Harvest BMP Effectiveness Summary

Study Site: O-01: Salmon Creek - Clearcut harvest, with RMZ and harvest without stream buffers

		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01	Effective					
	SR-02BU	Effective					
	SR-02NB			Not Effective			
	Photo Point (Skid Trails):						
	PS-01, PS-02, & PS-03	Effective					
	Erosion Pin Networks:						
	EP-01, EP-02, EP-03, & EP-04	Effective					
Case Narrative:	The RMZs were effective at preventing chronic sediment delivery directly to Salmon Creek and its buffered tributaries from activities or erosion features directly attributable to current harvest practices. Yarding within an RMZ resulted in erosion features which delivered to a Type 3 stream (SR01--1993), but delivery from these features did not persist. Windthrow, which may be indirectly associated with the clearcut harvest, and a pre-existing mass wasting feature are the primary source of sediment to Salmon Creek, which was buffered with a wider than required RMZ that extended to or nearly to the slope break at the edge of a steep inner gorge. Windthrow was severe in portions of the inner gorge. Gully development and other chronic erosion problems on skid trails (some of which entered the inner gorge and the RMZ) were prevented through the use of water bars and berms. Chronic sediment delivery to an unbuffered Type 5 stream was documented at the crossing of a major skid trail.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	No separate in-stream surveys were conducted.						
Case Narrative:	While no separate in-stream surveys were conducted at this site, sedimentation of the unbuffered Type 5 stream was observed. Fresh sediment deposits in a Type 3 stream were observed in 1993 associated with yarding activity within the RMZ, but delivery from these features was not chronic.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE		NOT EFFECTIVE			

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date(s)	2/18/93
Site Id #	O-01	Survey Id #	SR-01
Water Type	2, 3	Months Since Harvest	5

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	not recorded	not recorded	n/a
2	yarding	yes	not recorded	not recorded	n/a
3	yarding	yes	not recorded	not recorded	n/a
4	yarding	yes	not recorded	not recorded	n/a
5	skid trail	no	not recorded	not recorded	n/a
6	skid trail	no	not recorded	not recorded	n/a
7	yarding	no	not recorded	not recorded	n/a
8	skid trail	no	not recorded	not recorded	n/a
9	skid trail	no	not recorded	not recorded	n/a
10	yarding	no	not recorded	not recorded	n/a
11	windthrow	unknown	not recorded	not recorded	n/a
(Feature 11 includes several slide scars associated with windthrown trees along the inner gorge)					
12	skid trail	no	not recorded	not recorded	n/a
13	skid trail	no	not recorded	not recorded	n/a
14	skid trail	no	not recorded	not recorded	n/a
	TOTALS	3 delivered			

Total Area of Ground Surveyed = 2.8 hectares

Total Length of Stream Bank Surveyed = 713 meters

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features
skid trail	8
yarding	5
windthrow	1 (multiple trees along the inner gorge of Salmon creek)

NARRATIVE:

(Note: The sediment routing survey protocol was modified after this preliminary survey was conducted. Rather than measure features on the ground they were drawn on the aerial photo enlargements with the intent of scaling feature dimensions from the photos in the office, a procedure that proved to be inadequate for comparison with field measurements used in the final protocol. In addition, the degree of soil exposure for each feature was not determined in the field during this preliminary survey.) The forest practices evaluated were clearcut harvesting using ground-based equipment with RMZs, which were left along Salmon creek and a type 3 tributary. The erosion features caused by yarding that delivered sediment to streams were all within 10 meters of the type 3 tributary, and occurred when trees were harvested within the inner gorge. Due to the extremely steep and unstable soils within the inner gorge area along Salmon Creek, a RMZ was left that extended to the topographic slope break, substantially wider than required by the rules. Despite the wider buffer (average width of 43 meters in this area), windthrow was common on the steep slopes, leaving areas of exposed soils where rootwads had been torn loose and windthrown trees had slid down the inner gorge.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date(s)	5/11/94
Site Id #	O-01	Survey Id #	SR-01
Water Type	2, 3	Months Since Harvest	21

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	(no longer a feature--mostly revegetated)		
2	yarding	yes	3.2	0-25	0.3
3	yarding/wildlife	yes	0.8	0-25	0.1
4	yarding/wildlife	yes	3.4	0-25	0.4
5	skid trail	no	18.6	0-25	2.3
6	skid trail	no	67.8	25-50	25.4
7	yarding	no	(no longer a feature--revegetated)		
8	skid trail	no	25.2	0-25	3.2
9	skid trail	no	141.6	25-50	53.1
10	yarding	no	9.5	25-50	3.6
11A	windthrow	unknown	40.0	25-50	15.0
11B	windthrow	unknown	91.0	75-100	79.6
11C	windthrow	unknown	45.0	25-50	16.9
11D	windthrow	no	25.0	0-25	3.1
11E	windthrow	unknown	144.0	75-100	126.0
11F	windthrow	unknown	35.0	50-75	21.9
11G	windthrow	unknown	24	0-25	3.0
12	skid trail	no	32.5	0-25	4.1
13	skid trail	no	21.4	0-25	2.7
14	skid trail	no	103.6	25-50	38.9
15	windthrow	yes	13.0	25-50	4.9
16	windthrow	yes	6.2	0-25	0.8
17	windthrow	yes	4.6	0-25	0.6
18	windthrow	no	4.8	0-25	0.6
19	windthrow	yes	6.0	75-100	5.3
20	windthrow	yes	8.0	0-25	1.0
	TOTALS	8 delivered	874.2		412.8

Total Area of Ground Surveyed = 2.8 hectares

Total Length of Stream Bank Surveyed = 713 meters

Disturbed Soil per hectare = 312.2 m^2/hectare

Area Exposed Soil per hectare = 147.4 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered To Water = 13.4 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 4.8 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.8 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.3 m^2/hectare**

* The features that delivered to water but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	% of Total Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	7	129.7	31.4	0.0	0.0
yarding	4	4.4	1.1	0.8	6.0
windthrow	13	278.7	67.5	12.6	94.0

NARRATIVE:

The forest practices evaluated during this follow-up survey were clearcut harvesting using ground-based equipment, and RMZs which buffered Salmon Creek and a Type 3 tributary. As was the case in the 1993 survey, the erosion features that delivered sediment to streams were located within 10 meters of the stream, and were associated with harvesting activities within the RMZ and windthrow. Erosion of two yarding features identified in the 1993 survey was exacerbated by wildlife activity during the time between surveys. The rate of revegetation was faster for the yarding scars than for the skid trails. The number of windthrow increased between the 1993 and 1994 surveys, some of which delivered to surface waters. Erosion features directly attributable to harvest activities that continued to deliver sediment to streams were minimal, and do not represent a chronic erosion problem, hence the RMZs are rated as effective. Windthrow-related mass wasting along the inner gorge of Salmon Creek (features 11A-11G) does constitute a potentially large chronic source of sediment to the creek. The windthrow erosion scars on the valley wall ranged from 24 to 144 m^2 in size, and from mostly revegetated to mostly bare soil. Because of difficult access along the steep valley wall, we were not able to make direct observations of whether sediment was delivered to Salmon Creek for most of the features, but the potential for sediment delivery is high for some of the features. The amount of windthrow-related mass wasting appears to have increased substantially after the timber harvest, although some had occurred before the harvest (based on the stage of revegetation). Apparently, the new clear-cut affected the rate of windthrow by increasing exposure of RMZ trees within and adjacent to the inner gorge.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date	8/5/93
Site Id #	O-01	Survey Id #	SR-02BU
Water Type	2	Months Since Harvest	12

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
4	skid trail	no	70.2	not recorded	n/a
5	skid trail	no	292.8	not recorded	n/a
6	skid trail	no	218.9	not recorded	n/a
7	skid trail	no	549.0	not recorded	n/a
8	skid trail	no	102.8	not recorded	n/a
	TOTALS	0 delivered	1233.7		

Total Area of Ground Surveyed = 1.8 hectares

Total Length of Stream Bank Surveyed = 375 m.

Disturbed Soil per Hectare = 685.4 m^2/ha

Total Area Exposed Soil per Hectare = not determined

Total Disturbed Soil Area from All Erosion Features that Delivered to Water = 0 m^2

Disturbed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Disturbed Soil Area from Harvest Erosion Features that Delivered to Water = 0 m^2

Disturbed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Del. (based on area of disturbed soil)
skid trail	5	1233.7	0.0	0.0

NARRATIVE:

The SR-02BU survey includes the portion of the SR-02 survey area that is within the RMZ and that drains to streams buffered by the RMZ, including Salmon Creek, and the downstream segment of the type 5 stream. The feature numbers refer to the field survey photo map, which included both portions of the survey area. The forest practices evaluated were clearcut harvesting using ground-based equipment, with a RMZ along Salmon Creek. None of the erosion features identified in the survey delivered sediment to streams. The RMZ prevented direct sediment delivery to Salmon Creek and the lower segment of the type 5 stream. The degree of soil exposure was not determined in the field survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date	10/19/94
Site Id #	O-01	Survey Id #	SR-02BU
Water Type	2	Months Since Harvest	26

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
4	skid trail	no	62.4	25-50	23.4
5	skid trail	no	278.5	50-75	174.1
6	skid trail	(not resurveyed in 1994)			
7	skid trail	no	576.0	25-50	216.0
8	skid trail	no	39.4	25-50	14.8
13	windthrow	no	3.6	75-100	3.2
14	windthrow	no	32.0	75-100	28.0
15	falling	no	9.6	50-75	6.0
16	skid trail	no	83.0	50-75	51.9
17	yarding	no	9.3	50-75	5.8
18	skid trail	no	13.6	0-25	1.7
19	skid trail	no	27.4	25-50	10.3
20	yarding	no	20.0	25-50	7.5
21	mass wasting	yes	500.0	50-75	312.5
	TOTALS	1 delivered	1654.8		855.2

Total Area of Ground Surveyed = 1.8 hectares

Total Length of Stream Bank Surveyed = 375 m.

Disturbed Soil per Hectare = 919.3 m^2/ha

Total Area Exposed Soil per Hectare = 475.1 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 312.5 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 173.6 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* The features that delivered to water but were not directly attributable to current harvest practices, such as windthrow and the mass wasting noted as feature 21, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Del. (based on area of exposed soil)
skid trail	7	492.2	0.0	0.0
yarding	2	13.3	0.0	0.0
falling	1	6.0	0.0	0.0
windthrow	2	31.2	0.0	0.0
mass wasting	1	312.5	312.5	100

NARRATIVE:

The SR-02BU survey includes the portion of the SR-02 survey area that is within the RMZ and that drains to streams buffered by the RMZ, including Salmon Creek, and the downstream segment of the type 5 stream. The feature numbers refer to the field survey photo map, which included both portions of the survey area. The forest practices evaluated were clearcut harvesting using ground-based equipment, with a RMZ along Salmon Creek. Features 13-21 were not mapped as distinct erosion features during the 1993 survey, but were identified in 1994. The mass wasting feature is a valley wall slope failure within the inner gorge of Salmon Creek that was delivering fine sediment to Salmon Creek, and appears to be an old erosional feature possibly associated with the logging of the original forest. The RMZ continued to function as an effective buffer, preventing direct delivery of sediment to Salmon Creek from erosion associated with current harvest activities.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date	8/5/93
Site Id #	O-01	Survey Id #	SR-02NB
Water Type	5	Months Since Harvest	12

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	yes	126.0	not recorded	n/a
2	skid trail	yes	109.8	not recorded	n/a
3	skid trail	yes	120.2	not recorded	n/a
	TOTALS	3 delivered	356.0		

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 239 m.

Disturbed Soil per Hectare = 890.0 m^2/ha

Area Exposed Soil per Hectare = not determined

Total Disturbed Soil Area from All Erosion Features that Delivered to Water = 356.0 m^2

Disturbed Soil from All Erosion Features that Delivered per Hectare = 890 m^2/ha

Total Disturbed Soil Area from Harvest Erosion Features that Delivered to Water = 356.0 m^2

Disturbed Soil from Hectare Erosion Features that Delivered per Hectare = 890 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Del. (based on area of disturbed soil)
skid trail	3	356.0	356.0	100

NARRATIVE:

The SR-02NB survey includes the portion of the SR-02 survey area that drains to the un-buffered segment of the type 5 stream (*i.e.*, the segment that is upstream of the RMZ boundary). The feature numbers refer to the field survey photo map, which included both portions of the survey area. The forest practices evaluated were clearcut harvesting using ground-based equipment, without stream buffers. The three skid trail erosion features identified delivered fine sediment to the un-buffered type 5 stream. All three features were located within 10 meters of the stream, two of them at a major skid trail crossing. The degree of soil exposure was not determined in the field survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Salmon Creek	Survey Date	10/19/94
Site Id #	O-01	Survey Id #	SR-02NB
Water Type	5	Months Since Harvest	26

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	yes	132.1	50-75	82.6
2	skid trail	yes	135.7	25-50	50.9
3	skid trail	no	45.9	0-25	5.7
9	yarding	no	5.0	50-75	3.1
10	wildlife	yes	4.8	50-75	3.0
11	yarding	no	7.2	25-50	2.7
12	yarding	no	3.1	0-25	0.4
	TOTALS	3 delivered	333.8		148.4

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 239 m.

Disturbed Soil per Hectare = 834.5 m^2/ha

Area Exposed Soil per Hectare = 371.0 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 136.5 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 341.3 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 133.5 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 333.8 m^2/ha**

* The features that delivered to water but were not directly attributable to current harvest practices, such as wildlife activity, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Del. (based on area of exposed soil)
skid trail	3	139.2	133.5	97.8
yarding	3	6.2	0.0	0.0
falling	1	6.0	0.0	0.0
wildlife activity	1	3.0	3.0	2.2

NARRATIVE:

The SR-02NB survey includes the portion of the SR-02 survey area that drains to the un-buffered segment of the type 5 stream (*i.e.*, the segment that is upstream of the RMZ boundary). The feature numbers refer to the field survey photo map, which included both portions of the survey area. The forest practices evaluated were clearcut harvesting using ground-based equipment, without stream buffers. Features 9-12 were not mapped as distinct erosion features during the 1993 survey, but were identified in 1994. Two of the three skid trail features that were delivering fine sediment to the un-buffered type 5 during the 1993 survey were continuing to do so at the time of the 1994 survey. The chronic sediment delivery occurred where a major skid trail crossed the stream. A wildlife trail was also delivering small amounts of fine sediment to the type 5 stream in 1994.

BMP EFFECTIVENESS RATING:

Ground-based Yarding without stream buffers: NOT EFFECTIVE

Skid Trail Photo Point Survey Summary

Site: Salmon Creek O-01 Survey dates:11/17/92 & 3/29/94

Survey Id: PS-01

	Yes	No	Photo/Field Notes References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X				
2. Is there evidence of gully development or other chronic erosion problems? * w/exception of 1 small gully noted at a water bar outflow, and cutbank slumping		X*			Photo 5	
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters?	X					
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?	X					
5. Is there evidence that skid trails are re-vegetating? ** slow, natural re-vegetation.	X**					
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.* , other than natural re-vegetation)?		X				

Summary:

Survey PS-01 monitored conditions on a skid trail that entered below the slope break in the inner gorge along the edge of the Salmon Creek RMZ. The surveys were conducted to evaluate the effectiveness of water bars and other measures in preventing chronic erosion on skid trails, sediment delivery to streams, and to monitor the rate of revegetation of the soils exposed by the skid trails. The main findings of the PS-01 survey are: 1) the rate of natural revegetation was very slow in most sections of the skid trail; 7 of 9 transects were still >75% exposed over 18 months following timber harvest; 2) the water bars, in combination with a berm that was constructed along the downslope edge of the trail, were effective at preventing gully erosion and sediment delivery ; 3) a sediment plume downslope of a water bar outflow extended 2.6 meters downslope by the 1994 survey, but did not deliver to Salmon Creek; and 3) there was no evidence of fine sediment delivery to the Salmon Creek from this skid trail over the monitoring period.

BMP Effectiveness Rating: Effective

Skid Trail Photo Point Survey Summary

Site: Salmon Creek O-01 Survey dates:11/18/92 & 3.29/94

Survey Id: PS-02

	Yes	No	Photo/Field Notes References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X				
2. Is there evidence of gully development or other chronic erosion problems? *short gully forming just below slope break. 3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters?	X* X		Photo 9		Photo 22, 25	
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems? **No water bars constructed on this short spur skid trail.		X**				
5. Is there evidence that skid trails are re-vegetating? *** slow, natural re-vegetation. 6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.* , other than natural re-vegetation)?	X***	 X				

Summary:

Survey PS-02 monitored conditions on a short spur skid trail that was constructed over the slope break of the inner gorge just outside of the Salmon Creek RMZ, where it joined another skid trail that traversed the valley wall within the RMZ. The main findings of the PS-02 survey are: 1) the rate of natural revegetation was slow and patchy; 1 of 4 transects was still >75% exposed over 18 months following timber harvest, with 2 transects 50-75% exposed, and 1 25-50% exposed; 2) no water bars were constructed on this 25 meter skid trail, eroded sediment was stored on the skid trail below; and 3) there was no evidence of fine sediment delivery to the Salmon Creek from this skid trail over the monitoring period.

BMP Effectiveness Rating: Effective

Skid Trail Photo Point Survey Summary

Site: Salmon Creek O-01 Survey dates:11/18/92 & 3.29/94

Survey Id: PS-03

			Photo/Field Notes References			
	Yes	No	1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X				
2. Is there evidence of gully development or other chronic erosion problems? *no gullies but cutslopes are slumping, and windthrow along the cutslope side of trail has exposed a large scarp on the valley wall.	X*		Photo 9		Photo 22, 25	
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters? **a channel has begun to develop in the swale at the base of the skid trail, extending 10 meters downslope towards Salmon Creek.	X**					
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems? ***No water bars constructed on this short spur skid trail.	X***					
5. Is there evidence that skid trails are re-vegetating? (slow, natural re-vegetation.)	X					
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.*, other than natural re-vegetation)?		X				

Summary:

Survey PS-03 monitored conditions on a skid trail that began on relatively flat ground and then dropped over the slope break of the inner gorge along the edge of the Salmon Creek RMZ, then entered and traversed the valley wall within the RMZ. The main findings of the PS-03 survey are: 1) natural revegetation was slow and patchy; 3 of 7 transects were still >75% exposed over 18 months following timber harvest, with 2 transects 50-75% exposed, and 2 were 25-50% exposed; 2) the water bars were effective at preventing gully development; minor rilling was observed along with slumping and ravel of cutslope material. A berm was constructed along the downslope edge of the trail, which in combination with water bars was effective at preventing sediment delivery to Salmon Creek; 3) windthrow at the edge of the cutslope at a drainage swale caused a large 35 sq. meter slide scarp that had begun routing sediment downslope in the swale in which an erosion channel was forming ; and 4) there was no evidence of fine sediment delivery to the Salmon Creek from this skid trail over the monitoring period.

BMP Effectiveness Rating: Effective

Erosion Pin Network Survey Summary: Salmon Creek (Site O-01)
Survey Dates: 11/17/92 & 3/29/94

TRANSECT NUMBER	SLOPE TO NEXT TRANSECT (%)	RANGE OF EROSION* @ PINS (cm)	AVERAGE DEPTH OF EROSION* (cm)
Survey EP-01: Skid trail across slope break, traversing valley wall adjacent to the RMZ along Salmon Creek. Survey is co-located with Photo-Point Survey PS-01. Survey Length = 60 meters.			
01	18	1.2 to -3.6	-0.6
02	35	1.6 to -8.5	-1.5
03	24	2.7 to -8.8	-0.8
04	34	3.5 to -5.0	-0.4
05	25	2.9 to -30.5	-4.7
06	21	2.2 to -10.8	-2.1
07	n/a	-0.2 to -0.5	-0.4
Survey reflects localized erosion but overall aggradation of the skid trail, primarily due to accumulations of material eroded from cutbanks exposed during skid trail construction. No sediment delivery to Salmon Creek.			
Survey EP-02: Located on a sediment plume which extends downslope of the skid trail evaluated by EP-01, below a water bar diversion. Survey Length = 9.4 meters.			
01	n/a	2.9 to -0.3	0.5
02	n/a	4.3 to -7.1	0.8
03	n/a	4.3 to -7.1	-2
Survey reflects some erosion as well as continued deposition along the sediment plume. The plume had extended 2.6 meters farther downslope in the 16 months between surveys. No sediment delivery to Salmon Creek.			
Survey EP-03: Located on a spur skid trail running over the slope break and intersecting with the skid trail surveyed in EP-04. Co-located with Photo-Point Survey PS-02. Survey Length = 25.5 meters.			
01	n/a	1.2 to -1.3	-0.2
02	n/a	2.3 to -6.5	-0.9
Survey reflects both erosion and aggradation occurring on this short skid trail segment. No sediment delivery to Salmon Creek. Eroded sediment was stored on lower skid trail which was water-barred and bermed.			
Survey EP-04: Located on a skid trail which crosses the slope break and traverses the valley wall along the inner gorge of Salmon Creek, partially within the RMZ. Co-located with photo-point survey PS-03. Survey Length = 80 meters.			
01	25	3.1 to -0.7	0.5
02	23	1.9 to -1.0	0
03	23	3.4 to -3.5	0.3
04	35	-0.1 to -3.0	-1.6
05	27	3.1 to -17.0	-4.4
06	25	2.0 to -15.7	-2.4
07	35	3.2 to -25.6	-2
09	n/a	2.8 to -0.8	0.8
Survey reflects both erosion and aggradation along the skid trail. Aggradation is the result of accumulations of material from cutslope slumping and ravel. Some pins were buried by this and by sediment generated by windthrow of RMZ trees which took out part of the cutslope. Transect #8 pins could not be re-located. The trail was water-barred and bermed on the downslope side; there was no sediment delivery to Salmon Creek.			

(* Negative numbers indicate aggradation)

BMP Effectiveness Rating:
RMZ with Ground-based Yarding: EFFECTIVE

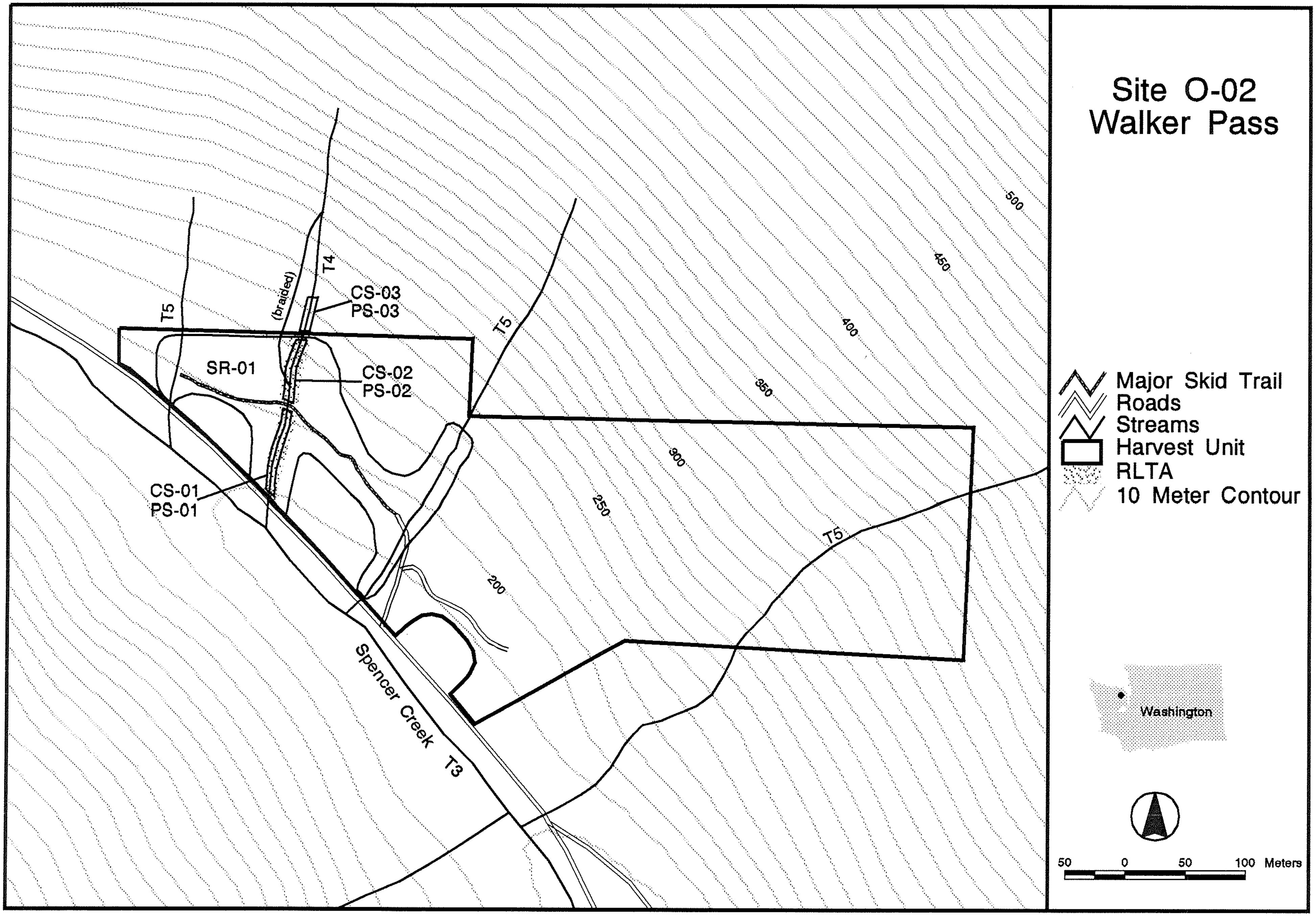
Site O-02: Walker Pass

The Walker Pass 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 site. Due to lack of soil mapping no soil hazard interpretations are available. The harvest BMP slope hazard category for the site is moderate. Side slope gradients along the study streams generally range from 20-40%.

The portion of the unit being evaluated for BMP effectiveness contains two zero order Type 5 tributaries and one zero order Type 4 tributary of Spencer Creek, which flows into Hood Canal near Putali Point. The Type 4 stream has a step-pool channel morphology with a V-shaped valley. The average channel gradient in the study reaches varies from 15% to 24%, with average active channel widths of 2.2 to 2.9 meters.

Forest practices conducted at this site include a 10 hectare clearcut harvest using both ground-based and cable-yarding methods, with a Riparian Leave Tree Area (RLTA) established along the Type 4 stream. The ground-based harvest occurred adjacent to the RLTA along the Type 4 stream and in the vicinity of the two Type 5 streams. The average width of the RLTA was 10 meters. A main skid trail crossed the RLTA using a temporary bridge, and it was also crossed by minor yarding routes. The two Type 5 streams were not buffered. Ground-based harvesting was completed in September of 1992.

The BMPs evaluated were the ground-based harvesting with a RLTA along the Type 4 stream, and the ground-based harvesting around the Type 5 streams without stream buffers. Three study reaches were established on the Type 4 stream. These include two treatment reaches within the unit, one above a major skid trail crossing and the other directly below it, and a control reach located immediately upstream of the unit boundary. Channel condition and photo point surveys were conducted on these study reaches in October 1992, October 1993, and September 1994. Sediment routing surveys were conducted in June 1993 and September 1994. The sediment routing survey area included the RLTA along the Type 4 stream and adjacent harvest areas in the vicinity of the un-buffered Type 5 streams. Estimates of the volume of sediment eroded and delivered to streams was made for selected erosion features identified during the 1994 sediment routing survey.



Site O-02
Walker Pass
Major Skid Trail
Roads
Streams
Harvest Unit
RLTA
10 Meter Contour
Washington
50 0 50 100 Meters
500
450
400
350
300
250
200
T5
T4
(braided)
CS-03
PS-03
SR-01
CS-02
PS-02
CS-01
PS-01
Spencer Creek T3

Harvest BMP Effectiveness Summary

Study Site: O-02: Walker Pass - Clearcut harvest, with RLTA and harvest without stream buffers

		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01BU					Not Effective	
	SR-01NB			Not Effective			
Case Narrative:	Chronic sediment delivery from harvest-attributable erosion features was documented in the area of the RLTA as well as where type 5 streams were not buffered. Where the RLTA practice was used, chronic sediment delivery was limited to skid trail crossings and one other yarding erosion feature, whereas more substantial amounts of chronic sediment delivery were observed in one of the un-buffered streams, particularly from a landing and temporary crossing.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01/CS-03					Effective	
	CS-02/CS-03					Effective	
	Photo Point:						
	PS-01/PS-03					Effective	
	PS-02/PS-03					Effective	
Case Narrative:	Although chronic sediment delivery to the buffered type 4 stream and bank disturbances were documented at skid trail crossings, the magnitude of localized direct impacts to this intermittant stream were not great. The steep gradient stream did not store fine sediment within the survey reaches. While no specific in-stream surveys were conducted in the un-buffered type 5 streams, substantial sedimentation was observed downstream of the temporary crossing and landing, resulting in a layer of fine sediment covering the entire active channel width to a depth of several centimeters in one of the type 5s. Above the temporary crossing, fresh sediment deposits were observed downslope of erosion features attributable to falling and yarding activities.						
	OVERALL SITE BMP EFFECTIVENESS RATING:			NOT EFFECTIVE		PARTIALLY EFFECTIVE	

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Walker Pass	Survey Date(s)	6/11/93
Site Id #	O-02	Survey Id #	SR-01BU
Water Type	4	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no	2.3	not recorded	n/a
2	windthrow	no	2.3	not recorded	n/a
3	windthrow	yes	2.5	not recorded	n/a
4	skid trail	yes	81.4	not recorded	n/a
5	skid trail	yes	56.6	not recorded	n/a
6	yarding	yes	20.5	not recorded	n/a
7	skid trail	yes	35.7	not recorded	n/a
8	skid trail	yes	51.9	not recorded	n/a
	TOTALS	6 delivered	253.2		

Total Area of Ground Surveyed = 0.9 hectare

Total Length of Stream Bank Surveyed = 132 m.

Disturbed Soil per Hectare = 281.3 m^2./hectare

Total Area Exposed Soil per Hectare = not determined

Total Disturbed Soil from All Erosion Features that Delivered to Water = 248.6 m^2

Disturbed Soil from All Erosion Features that Delivered per Hectare = 276.2 m^2./hectare

*** Total Disturbed Soil from Harvest Erosion Features that Delivered to Water = 246.1 meters^2**

*** Disturbed Soil from Harvest Erosion Features that Delivered per Hectare = 273.3 m^2./hectare**

*The features that delivered to water but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of disturbed soil)
yarding	2	22.8	20.5	8.3
windthrow	2	4.8	2.5	0.9
skid trail	4	225.6	225.6	90.8

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to the type 4 stream buffered by the RLTA. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvesting with ground-based yarding methods in the vicinity of a type 4 stream buffered with a riparian leave tree area (RLTA). The RLTA was effective at preventing direct sediment delivery to the type 4 stream except in the area of the skid trail crossings. A flat car trailer was placed across the channel at the main skid trail crossing to reduce stream bank and channel disturbance. However, this was not effective at preventing fine sediment delivery to the stream because of the inadequacy of soil stabilization/revegetation measures following the completion of harvest activities. Although water bars were installed to divert skid trail drainage, and this limited the source of sediment delivery to a localized area at the crossing, erosion with direct sediment delivery to the stream occurred downslope of the water bars. The other skid trail and yarding erosion features that delivered sediment were in direct connection with or within 10 meters of the stream. The degree of soil exposure was not determined in the field during this preliminary survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Walker Pass	Survey Date	9/7/94
Site Id #	O-02	Survey Id #	SR-01BU
Water Type	4	Months Since Harvest	23

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no longer a feature - mostly revegetated			
2	windthrow	no	1.2	25-50	0.5
3	windthrow	yes	1.7	50-75	1.1
4	skid trail	yes	80.0	50-75	50
5	skid trail	yes	56.4	0-25	7.1
6	yarding	yes	12.2	25-50	4.6
7	skid trail	yes	95.0	50-75	59.4
8	skid trail	yes	197.2	50-75	123.3
13	wildlife trail	yes	1.4	0-25	0.2
14	windthrow	no	1.5	25-50	0.6
15	yarding	no	2.2	50-75	1.4
	TOTALS	7 delivered	448.8		248.2

Total Area of Ground Surveyed = 0.9 hectares

Total Length of Stream Bank Surveyed = 132 meters

Disturbed Soil per Hectare = 498.7 m^2/hectare

Exposed Soil per hectare = 275.8 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 245.7 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 273.0 m^2/hectare

***Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 244.4 m^2.**

***Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 271.6 m^2/hectare**

* The features that delivered to water but were not directly attributable to current harvest practices, such as wildlife trails and windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trails	4	239.8	239.8	97.6
yarding	2	6.0	4.6	1.9
wildlife trail	1	0.2	0.2	<0.1
windthrow	3	2.2	1.1	0.5

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to the type 4 stream buffered by the RLTA. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvest with ground-based yarding methods in the vicinity of a type 4 stream buffered with a RLTA. This survey was a follow-up to that conducted on 6/11/93 to evaluate feature size, erosion status, degree of soil exposure, and delivery. Features 13-15 were not identified as individual erosion features in the 1993 survey, but were mapped in the 1994 survey. Feature 1 was a yarding scar identified in the 1993 survey, which had naturally revegetated to the point that it no longer met the minimum size criteria for an erosion feature. Features that delivered sediment to streams in 1993 were continuing to do so in 1994. The only new erosion feature identified in this survey in 1994 that delivered to the stream was a small wildlife trail. As in 1993, the RLTA was effective at preventing sediment delivery to the type 4 stream except at skid trail crossings and one yarding erosion feature within the RLTA. Skid trail features continued to deliver fine sediment via surface erosion and small gullies 23 months following completion of harvest activities.

BMP EFFECTIVENESS RATING:

RLTA (Ground-based Yarding): NOT EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Walker Pass	Survey Date(s)	6/11/93
Site Id #	O-02	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
9	skid trail	no	41.2	not recorded	n/a
10	skid trail	no	320.4	not recorded	n/a
11	skid trail	yes	77.0	not recorded	n/a
12	landing/temp. Xing	yes	305.8	not recorded	n/a
	TOTALS	2 delivered	744.4		

Total Area of Ground Surveyed = 0.7 hectares

Total Length of Stream Bank Surveyed = 229 m.

Disturbed Soil per Hectare = 1063.4 m^2/hectare

Total Area Exposed Soil per Hectare = not determined

Total Disturbed Soil from All Erosion Features that Delivered to Water = 382.8 $meters^2$

Disturbed Soil from All Erosion Features that Delivered per Hectare = 546.9 m^2/hectare

Total Disturbed Soil from Harvest Erosion Features that Delivered to Water = 382.8 $meters^2$

Disturbed Soil from Harvest Erosion Features that Delivered per Hectare = 546.9 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of disturbed soil)
skid trail	3	438.6	77.0	20.1
landing/temporary Xing	1	305.8	305.8	79.9

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the two un-buffered type 5 streams. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvesting with ground-based yarding methods in the vicinity of type 5 streams without stream buffers. One of the two un-buffered type 5 streams was impacted by a substantial amount of sediment delivery. A landing area that included a stream temporary crossing was the most significant source of sediment delivery to the type 5 stream. Downstream of the landing and crossing area, the streambed substrate was covered with a layer of fine sediment several centimeters thick. Delivery to this stream also occurred at a skid trail crossing. The other type 5 stream surveyed, which had a very small, discontinuous channel, had a skid trail crossing but no evidence of sediment routing to the stream via flowing water at the time of this initial survey. The degree of soil exposure was not determined in the field during this preliminary survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Walker Pass	Survey Date	9/7/94
Site Id #	O-02	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	23

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
9	skid trail	yes	17.9	0-25	2.2
10	skid trail	yes	135.0	25-50	50.6
11	skid trail	yes	51.2	25-50	19.2
12	landing/temp. Xing	yes	455.4	75-100	398.5
16	windthrow	yes	6.5	75-100	5.7
17	skid trail	no	24.6	0-25	3.1
18	yarding	no	8.0	25-50	3
19	yarding	yes	5.4	50-75	3.4
	TOTALS	6 delivered	704.0		485.7

Total Area of Ground Surveyed = 0.7 hectares

Total Length of Stream Bank Surveyed = 229 meters

Disturbed Soil per Hectare = 1005.7 m^2/hectare

Exposed Soil per hectare = 693.9 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 479.6 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 685.1 m^2/hectare

***Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 473.9 m^2.**

***Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 677.0 m^2/hectare**

* The features that delivered to water but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trails	4	75.1	72.0	15.0
yarding	2	6.4	3.4	0.7
landing /temporary Xing	1	398.5	398.5	83.1
windthrow	1	5.7	5.7	1.2

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the two un-buffered type 5 streams. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey include a clearcut harvest with ground-based yarding methods in the vicinity of type 5 streams without stream buffers. This survey was a follow-up to that conducted on 6/11/93 to evaluate feature size, erosion status, degree of soil exposure, and delivery. Features 16-19 were not identified as distinct erosion features in the 1993 survey, but mapped in the 1994 survey. Erosion features that delivered fine sediment to surface waters in 1993 were continuing to do so in 1994. Although no evidence of delivery from features 9 and 10 was observed in the 1993 survey conducted 8 months following the harvest, there was evidence of sediment routing to the type 5 stream (in the western part of the survey area) from these skid trail crossing features in 1994. The windthrow feature identified as delivering sediment to the other type 5 stream is a tree that blew down near the stream bank at the edge of the clearcut. Feature 12 is a landing area and temporary crossing of a type 5 stream, which resulted in stream bank destabilization and extensive and persistent sediment deposition in the stream.

BMP EFFECTIVENESS RATING:

Ground-based Yarding with no buffers: NOT EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Walker Pass O-02

Treatment Survey ID#: CS-01 and CS-02 — Water Type: 4
Control Survey ID#: CS-03 — Water Type: 4

BMP(s) Evaluated: Ground-based Harvest (Clear Cut) with RLTA

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-01	CS-02			
Initial Survey*:	52	52	10/1/92	52	10/1/92
Post-Treatment Survey #1:	59	59	10/15/93	56	10/15/93
Change from Pre-Treatment Score:	+7	+7		+4	
Net Change (Control-Treatment):	+3	+3			
Post-Treatment Survey #2:	40	39	9/7/94	45	9/7/94
Change from Pre-Treatment Score:	-12	-13		-7	
Net Change (Control-Treatment):	-5	-6			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:

[* Note: Initial surveys were conducted while harvest operations were ongoing at the unit. Falling and yarding had been completed on the ground-based harvest area in the vicinity of the RLTA by September 1992, but were continuing on the cable-yarding portions of the unit.]

Scores for both treatment and control reaches showed a decrease over the two year study period, after first increasing between 1992 and 1993. The two treatment reaches are on the same stream, separated by a main skid trail crossing which had been temporarily bridged by a flat-car trailer; the CS-01 reach is below the crossing. The control reach is located on the same stream, immediately upstream of the treatment reaches and the harvest unit. The greatest degree of harvest-related stream channel disturbance was in the immediate vicinity of the crossing and other minor skid trail crossings. In addition to direct disturbance at the skidder crossings, Sediment Routing surveys documented sediment delivery to the stream from other yarding-related erosion features along the RLTA. The study stream is an intermittent Type 4 with average gradient being 15-20% within the treatment reaches, and has a low potential for storing fine sediments, as reflected in the survey results from all three years. The net decrease in treatment reach scores, as compared to control reach scores, is primarily due to increases in stream bank erosion and flow deflection into banks from slash, as well as increases in fresh deposits of gravel-sized material.

In-Stream Photo-Point Survey Comparison Summary

Site: Walker Pass O-02 Survey Dates: 10/1/92, 10/15/93, & 9/7/94

Study Reach Descriptions: 69m treatment reach below major skid trail crossing, 52m above crossing, and 26m control reach on same stream upstream of harvest unit.

Indicators of in-channel changes	Control PS-03 Yes	Control PS-03 No	Treatment PS-01 & PS-02 Yes	Treatment PS-01 & PS-02 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X		X	
4. Is there evidence of increased deposition or storage of fine or coarse sediment? *deposition of gravels and fines downstream of skid trail crossing in 93 svy; deposit was no longer there in 94 svy.		X	X*	
5. Are there changes in woody debris? (indicate numbers of windthrown trees documented over the survey period) — Increase in large WD?		X	X**	
Increase in small WD?		X	X	
Decrease in WD? **2 new windthrown trees across the channel in treatment reach	X			X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?	X		X	

Summary:

Only minor changes were observed over the monitoring period in both treatment and control reaches. Mosses on streambed cobbles were scoured off; this occurred in both treatment and control reaches. One or more bed mobilizing flow events affected both treatment and control reaches. A deposit of gravels and fine sediment observed downstream of major skid trail crossing did not persist. Channel morphology and steam energy are such that the potential to store fine sediment is low.

BMP Effectiveness Rating: Effective

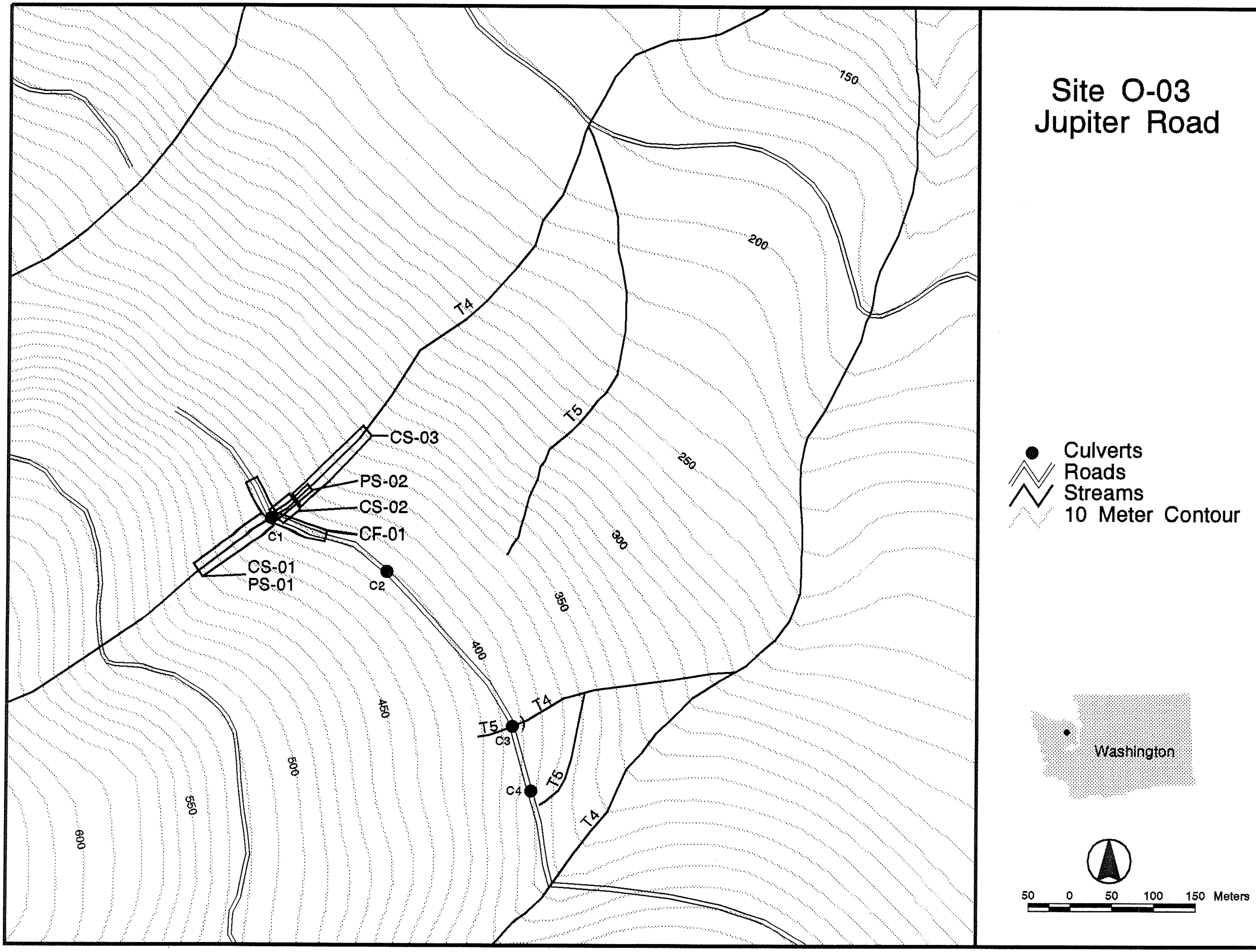
Site O-03: Jupiter Road

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 road construction BMP slope hazard category is high. Hillslope gradients at the main stream crossing range from 64% to 72%.

The new road crosses a 1st order, Type 4 stream and a zero order Type 5 stream, both tributaries to the Dosewallips River which flows into Hood Canal. The 1st order stream meets the criteria for a Type 4 based on its physical characteristics, but was depicted as a Type 5 on DNR water type maps and the FPA. This stream has a cascade channel morphology, with a V-shaped valley. Average active channel width in the study reaches ranges from 5 to 7 meters, with average channel gradients of 42% to 45%. The Type 5 stream crossed by the new road construction was not typed on the water type maps. This stream becomes a Type 4 just downstream of the road crossing, and has a Type 5 tributary with a channel head located just downslope of the new construction.

Forest practices conducted at this site include 0.4 km of new road construction along steep slopes. The new road segment has two culverted stream crossings and two relief culverts. The road construction was completed by September 1992.

The BMPs evaluated were the water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Three study reaches were established on the larger, Type 4 stream. Channel condition surveys were conducted on two treatment reaches downstream of the road crossing and one control reach upstream of the road crossing in September 1992, October 1993, and July 1994. Photo point surveys were conducted on the upstream control and one of the treatment reaches in October 1992, October 1993, and July 1994. Culvert condition surveys of the entire new road segment were conducted in October 1992, October 1993, and July 1994. Cutbank/fillslope surveys were conducted on the segment draining to the Type 4 crossing in July 1993 and July 1994. Follow-up investigations were conducted in March 1995 to evaluate sediment routing below the road during wet weather conditions and make measurements of gully erosion. At the time of these follow-up investigations, the area below the road was being clearcut harvested, with RLTAs left along the streams.



Site O-03
Jupiter Road
Culverts
Roads
Streams
10 Meter Contour
Washington
50 0 50 100 150 Meters
150
200
250
300
350
400
450
500
550
600
T4
T5
CS-03
PS-02
CS-02
CF-01
CS-01
PS-01
C1
C2
C3
C4

Road BMP Effectiveness Summary

Study Site: O-03: Jupiter Road - New Road Construction

		BMP Effectiveness Ratings			
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings WAC 222-24-040	Relief WAC 222-24-025	Cutslopes WAC 222-24-030	Fillslopes
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition:				
	CC-01	Not Effective	Effective		
	Cutbank/Fillslope:				
	CF-01			Not Effective	Not Effective

Case Narrative: Relief culverts did not deliver sediment to streams over the monitoring period, and are rated effective. Channelized sediment transport distances downslope of relief outfalls ranged from 10 to 50 meters. There was substantial erosion, including gullying of the very large fill at the Type 4 crossing, and gullying of cut slopes, with chronic sediment delivery to streams at both road crossings. An estimated 25 m^3 of sediment was eroded and delivered from gully erosion on the fill over the Type 4 alone. Gullies persist on the culvert fill and on cutslopes despite otherwise vigorous growth of grass/clover following hydromulching the first spring after construction. One problem observed was the filling of the ditches due to gullying and sloughing of cutslopes, which apparently diverted drainage across the road onto fillslopes, combined with the fact that the road surface was crowned/outsloped as it approached the stream crossing. Chronic delivery from fillslopes was not limited to localized erosion of the culvert fill, but also included delivery of material eroded from the cutslope, ditch, and road surface which was diverted across the fill. Fillslope erosion was also found to be a source of sediment to a type 5 stream that was located just downslope of another section of the new road construction.

ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:				
	CS-02/CS-01	Not Effective		Not Effective	Not Effective
	CS-03/CS-01	Not Effective		Not Effective	Not Effective
	Photo-Point:				
	PS-02/PS-01	Indeterminate		Indeterminate	Indeterminate

Case Narrative: The photo point surveys are rated "indeterminate" due to interferences that affected the upstream control reach. Between the second and third years of surveys, a channel destabilizing peak flow event affected the study stream. It was evident, however, that the reach downstream of the road experienced greater effects, particularly increased bank erosion and excavation of large sediment wedges, and this is reflected in the comparison of channel condition surveys. Particularly in the CS-03 reach, the net increase (treatment over control) in channel destabilization was substantial, and this is attributed to the added effects of road drainage (runoff plus sediment), and well as flow concentration at the culvert, which appears to be under-sized for this channel that is over 6 meters wide. In the CS-02 reach just below the road crossing, fresh deposits of material eroded from the road segment and culvert fill was observed on the surface of sediment wedges formed upslope of streambed obstructions.

	OVERALL SITE BMP EFFECTIVENESS RATING:	NOT EFFECTIVE	EFFECTIVE	NOT EFFECTIVE	NOT EFFECTIVE

Jupiter Road Culvert Condition Survey Results

Site: O-03: Jupiter Road
Culvert Condition Survey: CC-01

Survey Dates: 10/92, 10/93, and 7/94.
Date of construction: 9/92

Site BMP Effectiveness Ratings:

Stream X-ing: Not effective
Relief: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Year 1992	1993	1994	Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-1, T-4 x-ing	Inflow	Moderate	Slight	Slight	n/a	Decrease	Y		Yes, Type 4	No
	Outflow	Severe	Moderate	Moderate	(127m)	Decrease	Y			
C-2, Relief	Inflow	Slight	Slight	Slight	149m	Constant	Y		No	Yes
	Outflow	Moderate	Moderate	Moderate	(178m)	Constant	Y	Yes, 50M down slope		
C-3, T-5 x-ing	Inflow	Slight	Moderate	Slight	239m	Variable	Y		Yes, Type 4/5	No
	Outflow	Slight	Moderate	Moderate	(136m)	Increase	Y			
C-4, Relief	Inflow	No call	Slight	Moderate	74m	Increase	Y		No	Yes
	Outflow	Slight	Moderate	Moderate	(114m)	Increase	Y	Yes, 10M down slope		

Comments/ Notes Summary:

The total distance surveyed was 608 meters (1,994 feet) with an average distance between culverts of 152m. (499 feet). The average road gradient was 4 % with a range of 0-10 %, while the hillslope gradient averaged 57 % with a range of 35-74 %. In general, armoring of the culvert inflows was rated "good", with the outflows rated "fair" to "poor". Plugging of culverts was 0% for all culverts, except that the inflow to C-1 was 20% plugged in 1994. C-1 was a 36-inch pipe used for a crossing of a type 4 stream which had an active channel width of 5-7 meters. Road construction was completed in September of 1992, by late October, when the first survey was conducted, the very large fillslope at culvert 1 was beginning to gully. A grass/clover mix and hydromulch were applied to stabilize the exposed soils of the cutslopes, portions of fillslopes near stream crossings, and portions of the road tread between October of 1992 and October of 1993. By October, 1993, the amount of exposed soil had been greatly reduced on many areas of the road prism, including the cutslopes. At the time of the 1994 survey, however, the gullies which had developed on the fill at culvert 1 persisted (these gullies accounted for 25 cubic meters of sediment eroded with direct delivery to the stream), and surface erosion processes at culvert 3 continued to deliver sediment to the stream, resulting in a not effective call. Fresh sediment deposits (mostly gravel-sized) were observed on sediment wedges formed behind obstructions within the steep intermittent streams, with obvious deposits noted at least 50 meters downstream of C3 in 1994, and the channel (type 5 above the road, type 4 below) appeared to be widening. As can be seen from summary above, the extent of erosion remained at slight or moderate for both the 1993 and 1994 surveys, an indication of the partial effectiveness of grass seeding/hydromulching as a soil stabilization BMP (e.g. for areas which did not gully). The relief culverts 2 and 4 were rated effective because they did not deliver to surface waters, however, channel initiation and sediment movement was documented below the outflow of each pipe. A type 5 stream about 50m. downslope of C-4 had fresh fine sediment deposits, but no channel or sediment plume was observed extending greater than 10m. below C-4. The site was visited during wet conditions in March of 1995 to determine the source of sediments to this type 5. It was determined that the source was the fillslope to the southeast of C-4; the type 5 channel was not crossed by the road, but the channel initiated at a knickpoint just downslope of the road prism. During the March 1995 site visit a logging operation was in progress, and the road, which was quite wet and muddy, was not surfaced. Delivery of turbid drainage was observed at C-1 via ditches to the culvert inflow, as well as runoff across the fill slope via gullies.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Jupiter Road
Survey ID #'s	CF-01
Survey Dates	7/6/93 & 7/13/94, with follow-up observations on 3/95
Water Type	4
Construction Date:	9/92
Length Road Draining to Stream	127 meters

Range Road Gradient	0-8 %
Average Road Gradient	4 %
Range Hillslope Gradient	35-74 %
Average Hillslope Gradient	57%
Range Cutslope Gradient	37-50 deg.
Average Cutslope Gradient	41 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	0		0	
% Observations w/med. slope height	40		60	
% Observations w/high slope height	60		40	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	100	0	40
% Observations w/26-50 % exposed soils	100	0	80	20
% Observations w/51-75 % exposed soils	0	0	0	0
% Observations w/76-100 % exposed soils	0	0	20	40
% Observations w/Evidence of Erosion	100	60	80	80
Evidence of Erosion w/delivery to surface water	yes	yes	yes	yes
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	yes	yes
BMP Effectiveness Ratings:	**Not Effective**		**Not Effective**	

COMMENTS:
Although a rock surfacing was not placed on the road surface, a site compliance visit conducted on 2/17/93 determined that the road met minimum BMPs. It was noted during this inspection that the cutslopes and the fill at the stream crossing were eroding and delivering sediment to the stream. Grass seed/hydromulch was applied to the cutslopes and the fill in the area of the surveyed stream crossing following road construction in the fall of 1992. During a site visit on 10/14/93 it was noted that the hydromulch and grass seeding appeared to be effective at stabilizing erosion of the cutslope, except where gullies had developed. A non-functioning ditch (plugged from cutslope failures) contributed to erosion of and gully formation on the large fill at the stream crossing. During the CF-01 survey conducted on 7/13/94 it was noted that the hydromulch/grass seeding continued to be effective at stabilizing surface erosion, but that gully erosion was continuing. Continued delivery of eroded cutslope material to the east of crossing occurred via the road surface and fillslope, but not via ditch which became filled due to storage of material eroded from cutslope in fall/winter of 1992/93. Delivery from fillslope erosion was occurring at the culvert location, however, this reflected not only localized erosion of the culvert fill but also drainage from the road surface and cutslope/ditch erosion which was diverted across the fill at times. This drainage diversion across the large fillslope (approx. 15m slope length) contributed to the development of persistent gullies. Measurements of these gullies in March 1995 indicated that 25.2 m^2 of eroded sediment from fill gullies alone was delivered directly to the type 4 stream. Also during the March 1995 site visit, fillslope erosion within another section of the road (near culvert C4; not included in the CF-01 drainage segment) were found to be a source of sediment delivery to a zero order type 5 stream that began just downslope of the road.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Jupiter Road O-03

Treatment Survey ID#: CS-02 & CS-03 Water Type: 4
Control Survey ID#: CS-01 Water Type: 4

BMP(s) Evaluated: New Road Construction (Road Drainage Design, Construction Techniques, and Stream Crossings)

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-02	CS-03			
Pre-Treatment Surveys:	54	57	9/1/92	57	9/1/92
Post-Treatment Survey #1:	54	57	10/19/93	56	10/14/93
Change from Pre-Treatment Score:	0	0		-1	
Net Change (Control-Treatment):	+1	+1			
Post-Treatment Survey #2:	32	31	7/19/94	45	7/13/94
Change from Pre-Treatment Score:	-22	-26		-12	
Net Change (Control-Treatment):	-10	-14			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:
The net decrease in treatment reach scores is attributable primarily to an increase in bank erosion and flow deflection into banks in the treatment reaches. Both control and treatment reaches experienced a destabilization of stair-step (sediment storage) control elements, and increases in fresh sediment deposits and bed mobility. Survey results, including observations noted in the comments section, indicate that both treatment and control reaches were impacted by a peak flow event in the second year, with destabilization of sediment wedges increasing in a downstream direction. There was evidence of excavation of sediment wedges in the CS-03 reach (e.g. distinct moss lines defining the previous elevations of sediment deposits), with losses of up to 1 meter of vertical deposit from some wedges, as noted in the photo point survey. A minor valley wall slide (alongside an old growth cull log) was noted in the control reach, resulting in fresh sediment deposits in the channel. In the reach immediately downstream of the road (CS-02), fresh deposits from gullying of the road fill were noted on top of sediment wedges, as well as root wads and boulders tumbling down from the road fill causing minor valley wall disturbance. The most likely localized stream impacts which could result from the road construction BMPs evaluated at this site are sedimentation of the stream bed, destabilization of channel bed and banks due to road drainage impacts, and turbidity increases during runoff events. The overall morphology and substrate character of the study reaches indicate a low potential for storage and accumulation of fines within the reaches. The stream is very steep with channel gradients of 42-45%. Stream morphology is characterized by a series of relatively low gradient sediment wedges punctuated by near vertical steps. The greater magnitude of channel destabilization in the CS-03 treatment reach is attributed in part to road drainage effects (runoff plus sediment). Flow concentration at the culvert may also have been a factor; the culvert appears to be under-sized for this stream (a 1 meter diameter pipe in a stream with an active channel width of over 6 meters).

In-Stream Photo-Point Survey Comparison Summary

Site: Jupiter Road — Survey Years: 10/92, 10/93, & 7/94.

Study Reach Descriptions: 56 m. treatment reach in type 4 stream; control reach is 103 m. on same type 4 stream, immediately upstream of new road crossing.

Indicators of in-channel changes		Control PS-01 Yes	Control PS-01 No	Treatment PS-02 Yes	Treatment PS-02 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X		X	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X		X	
4. Is there evidence of increased deposition or storage of fine or course sediment?		X		X	
5. Are there changes in woody debris? (a single windthrow was documented along the control reach; no windthrow was documented in the treatment reach.)	Increase in large WD?		X		X
	Increase in small WD	X		X	
	Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?		X		X	

Summary:

A bed mobilizing flow occurred within this type 4 channel between the 1993 and 1994 survey years, impacting both the treatment and control reaches. Between 1992 and 1993, little change was detected within either reach by the photo point networks. While the magnitude of change detected during the 1994 surveys, was slightly greater in the treatment reach, (larger pieces of wood were moved and greater area of the channel was disturbed), it is not possible to attribute these changes solely to presence of the road. There is an old road crossing the stream above the control reach, with a failing puncheon culvert (partially plugged at the inflow with a portion of the stream routed across the road surface). This crossing may be influencing channel stability within the study reaches. Interference in the control-treatment comparison leads to an "Indeterminate" call for this survey.

BMP Effectiveness Rating: Indeterminate

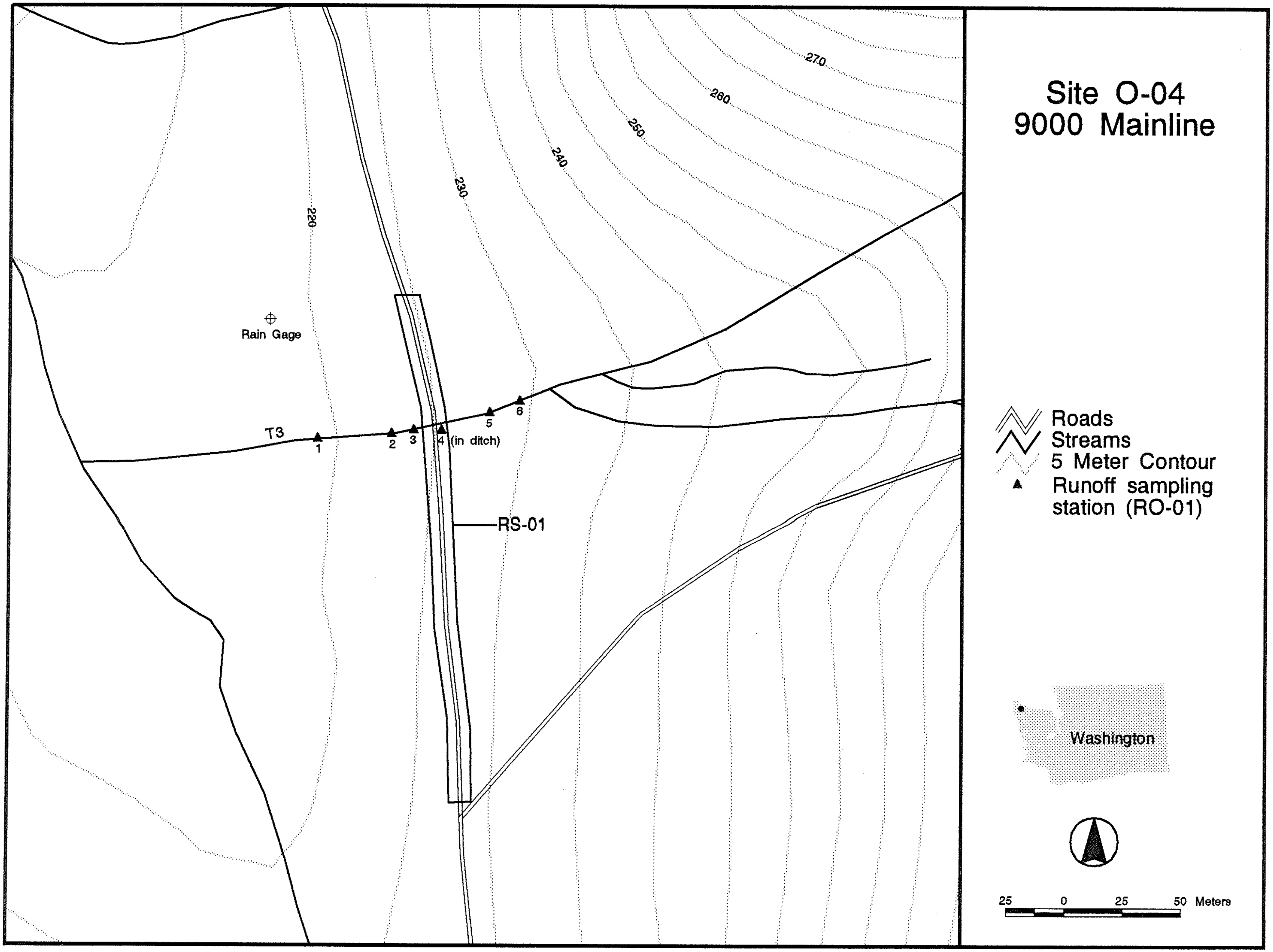
Site O-04: 9000 Mainline

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. Side slope gradients range from 18-33% at the stream crossing.

The haul road crosses a zero order, Type 3 tributary to the Hoko River, which flows into the Strait of Juan De Fuca at Kydaka Point. This stream meets 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 meters below the road and 6 meters above the road, with average channel gradients of 3% and 5% for the downstream and upstream reaches, respectively.

Active, mainline haul road maintenance BMPs were evaluated at this site. According to landowner representatives, maintenance schedules varied according to traffic volume, weather conditions, and road-bed integrity.

Channel condition surveys were conducted both up and down stream of the road crossing to evaluate in-stream sediment sources and comparability of the study reaches. In January of 1994, runoff sampling was conducted concurrent with a road surface condition survey. Although sampling was scheduled to coincide with a rainfall-runoff event that had been forecast, the event never materialized, and the rain gauge and stream stage recorder at the site revealed only a trace of rain and a receding hydrograph during the sampling period.


Site O-04
9000 Mainline
270
260
250
240
230
220
Rain Gage
T3
1
2
3
4 (in ditch)
5
6
RS-01
Roads
Streams
5 Meter Contour
Runoff sampling station (RO-01)
Washington
25 0 25 50 Meters

Active Haul Road Maintenance BMP Effectiveness Summary

Study Site:	O-04: 9000 Mainline Road - Active haul road maintenance practices	
	Survey Employed	**BMP Effectiveness Ratings** Active Haul Road Maintenance WAC 222-24-050(2) & (4)
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Road Surface Condition Survey: RS-01	Indeterminate
Case Narrative:	An indeterminate call is given because the survey was not conducted during a runoff event. However, surveys conducted during a light rain event representative of winter base flow conditions generally reflected a travelway adequately maintained along the study segment for such ambient conditions, with the thickness of fines on the road surface less than 1 cm in the center of the road, and generally 2-10 cm along the edges of the travelway. No rutting or rilling of the road surface was apparent. Ditchlines and cut and fill slopes were well-vegetated. Traffic on the day of sampling included 36 heavy vehicles (11 loaded log trucks, 10 unloaded log trucks, and 15 loaded dump trucks) and 21 light vehicles over a 7.5 hour period.	
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Runoff Sampling: RO-01	Indeterminate
Case Narrative:	The survey is given an indeterminate call because sampling was not representative of a runoff event. Water sampling indicated some transport of colloidal fines in ditches via base flow (very slightly turbid ditch flow of 2.5 NTU compared to less than 1 NTU in the stream), but no influence from the road drainage was apparent in either turbidity or total suspended solids results from stream sampling above and below the road. Stream discharge measurements taken on the day of sampling indicated a 35% increase in streamflow from the upstream gauging site to the downstream gauging site. However, the only suitable upstream gauging site was above two small springs and a large sediment wedge where a considerable amount of upwelling was observed. Most of the flow increase between the upstream and downstream gauging stations was attributed to the springs and inter-gravel flow through the sediment wedge, with a minor portion attributable to road drainage. The recording stage height recorder showed a drop of 2-3 cm. over a 24 hour period, and the on-site rain gauge recorded only a trace of precipitation, confirming the lack of a runoff event.	
	OVERALL SITE BMP EFFECTIVENESS RATING:	INDETERMINATE

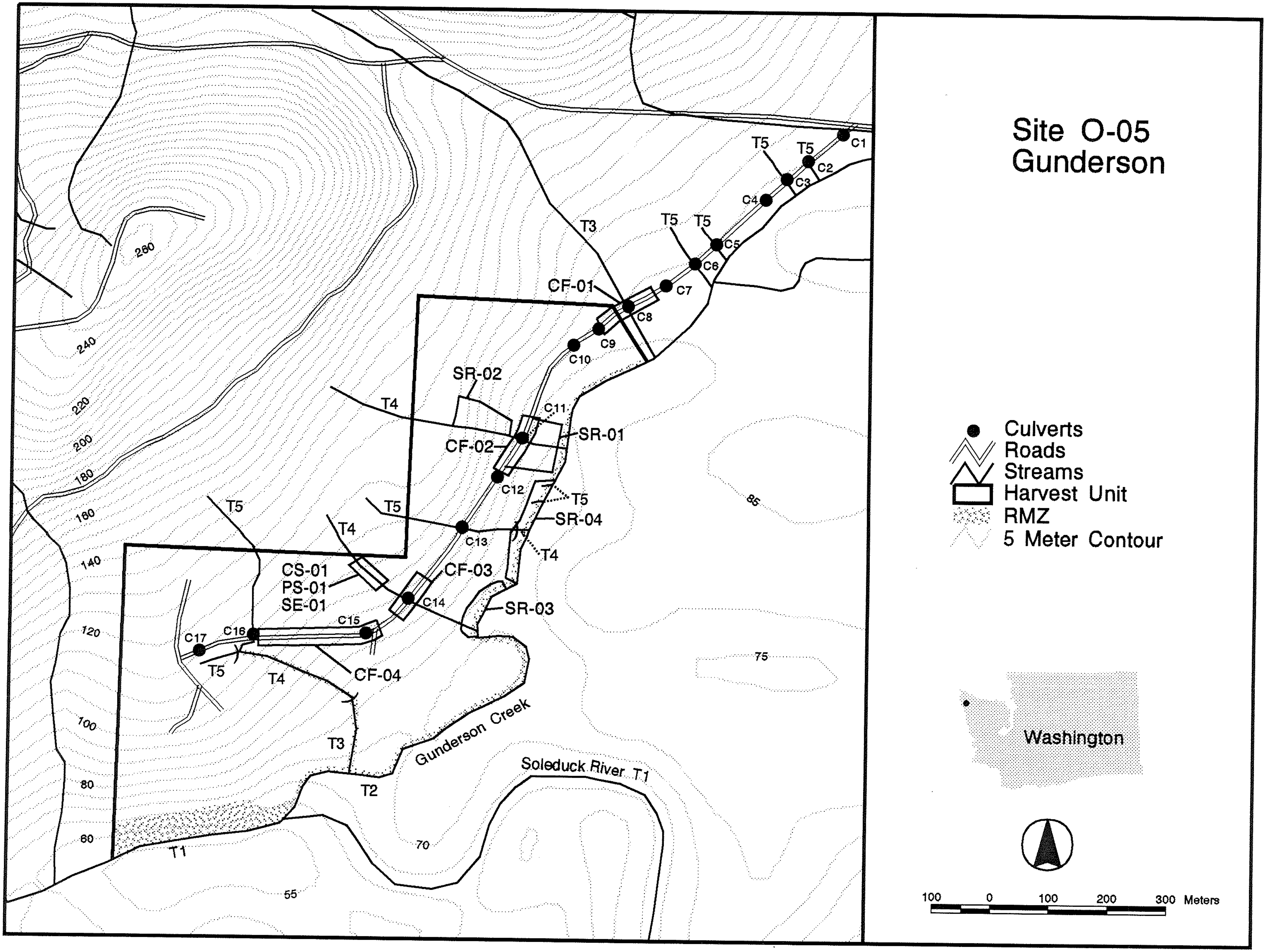
Site O-05: Gunderson Creek

Gunderson Creek is a harvest and new road construction site 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. The 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 BMP slope hazard category is high due to steep inner gorges along the streams, with maximum side slope gradients exceeding 100% in one of the survey areas. The road construction BMP slope hazard category is low to moderate for four segments of the road surveyed, where hillslope gradients range from 8-31%.

The harvest unit is bordered by Gunderson Creek, a 2nd order Type 2 stream, and the Soleduck River, a Type 1+ water. Within the harvest unit are four zero order tributaries to Gunderson Creek, plus two very short Type 5 "wall-based channels" within the RMZ along Gunderson Creek. Gunderson Creek enters the Soleduck River at the southern boundary of the unit. Of the four zero order streams within the harvest unit, one is a Type 3, changing to a Type 4 and then branching into two Type 5 tributaries. The other three are Type 4s, one of which changes to a Type 5 for most of its length in the unit. Two of the Type 4 streams selected for surveys evaluating harvest BMPs have average channel gradients of about 10%, and active channel widths of about 2 meters. Five additional zero order streams are located outside of the harvest unit, crossed by the new road construction that provides access to the unit. One of these is a Type 3, and the remainder are short Type 5 channels which were un-typed on the FPA water type map.

Forest practices included a 45 hectare clearcut harvest with 1.1 km of new road construction, about 0.8 km of which is located within the harvest unit itself. The road parallels Gunderson Creek, and runs along the valley bottom and side slope. Road construction was completed in October of 1992. Harvest was conducted using both ground-based (shovels) and cable yarding practices. RMZs were established on the Soleduck River, Gunderson Creek and the Type 3 tributary. The width of the RMZ along Gunderson Creek averaged 21 meters and 61 meters in two survey areas. Areas around the Type 4s and 5s were harvested without stream buffers. The harvest was completed in January of 1994. Site preparation activities conducted concurrent with the completion of ground-based harvesting included slash piling with shovel equipment.

Harvest BMPs evaluated at this site include the RMZ along Gunderson Creek and harvest in the vicinity of two of the un-buffered Type 4 streams, including both ground-based and cable yarding practices. In-stream study reaches established to evaluate harvest BMPs included a treatment reach on one of the Type 4 streams, and a control reach located outside of the unit boundary. Subsequent to the initial stream surveys, the landowner of the site containing the control reach initiated a harvest of the site in 1994, which compromised the control function of this reach. However, an RMZ was left along the control reach, allowing some level of comparison with the unbuffered Type 4. Channel condition and photo point surveys were conducted on the study reaches in July 1993, May 1994, and July 1995. Stream bank erosion surveys were conducted in July 1993 and August 1994. Sediment routing surveys were conducted in four different areas of the harvest unit in August and October of 1994 and July 1995. Estimates of the volume of sediment eroded and delivered to streams was made for selected erosion features identified during the 1995 sediment routing surveys. New road construction BMPs evaluated include water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Culvert condition surveys were conducted in June 1993, May 1994, and July 1995. Cutbank/fillslope surveys were conducted on four different road drainage segments in July 1993 and May 1994.



Site O-05
Gunderson
Culverts
Roads
Streams
Harvest Unit
RMZ
5 Meter Contour
Washington
100 0 100 200 300 Meters
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16 C17
T1 T2 T3 T4 T5
CF-01 CF-02 CF-03 CF-04
SR-01 SR-02 SR-03 SR-04
CS-01
PS-01
SE-01
Gunderson Creek
Soleduck River T1
280 240 220 200 180 160 140 120 100 80 60 55 70 75 85

Harvest BMP Effectiveness Summary

Study Site:	O-05: Gunderson Creek - Clearcut harvest, with RMZ and harvest without stream buffers						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01			Not Effective			
	SR-02				Not Effective		
	SR-03BU	Effective					
	SR-03NB			Not Effective			
	SR-04	Effective					
Case Narrative:	The sediment routing surveys showed substantial differences between harvest with and without buffers at the same harvest unit. For surveys conducted during the first year following timber harvest, soil disturbance ranged from 2-9% of the survey areas for the RMZ practice, versus 10-50% of the survey areas for harvest without buffers. In evaluations of the RMZ reach, the only erosion features delivering sediment directly to the buffered stream were associated with windthrow. There was no evidence that the RMZ had been entered to harvest trees. By contrast, there was substantial disturbance of stream banks and valley walls with chronic sediment delivery in areas where type 4 streams weren't buffered. Erosion features which delivered were primarily associated with yarding activities and falling and shovel trails adjacent to and crossing the streams.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01			Not Effective	Not Effective		
	Photo Point:						
	PS-01			Not Effective	Not Effective		
	Stream Bank Erosion:						
	SE-01			Not Effective	Not Effective		
Case Narrative:	Channel condition surveys in the unbuffered type 4 documented a fining of the streambed, especially in pools, increased streambed mobility, and destabilization of sediment storage elements and stream banks following the harvest, with a decrease in channel condition scores of 60% and 35%, respectively, in the first and second year following the harvest. Photo point networks documented the disturbance, but also a significant amount of revegetation of stream banks during the second year of recovery. The extent of actively eroding stream banks went from 27% of total bank length before the harvest to 44% the first year following the harvest. Prior to the harvest, active erosion was limited to lower banks, but following the harvest it included upper banks as well, with the total surface area of actively eroding banks increasing from 31 m^2 before harvest to 76 m^2 following harvest.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE		NOT EFFECTIVE	NOT EFFECTIVE		

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date(s)	8/2/94
Site Id #	O-05	Survey Id #	SR-01
Water Type	4	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	yes	12.0	0-25	1.5
2	yarding/falling	yes	3.4	50-75	2.2
3	yarding/falling	yes	80.0	75-100	70.0
4	yarding	no	13.3	75-100	11.7
5	falling	no	4.5	25-50	1.7
6	yarding/falling	yes	21.6	25-50	8.1
7	shovel trail	yes	136.0	75-100	119.0
8	yarding/falling	yes	21.0	25-50	7.9
9	shovel trail	yes	383.0	50-75	239.4
10	yarding/falling	yes	51.0	0-25	6.4
11	yarding	no	3.2	75-100	2.8
12	yarding/falling	yes	19.6	75-100	17.2
13	yarding/site prep.	yes	222.2	25-50	83.4
14	yarding	yes	23.1	50-75	14.5
15	yarding/falling	yes	8.7	50-75	5.5
16	yarding/falling	no	20.5	50-75	12.9
17	yarding/falling	no	9.9	0-25	1.3
18	falling	yes	1.8	75-100	1.6
19	yarding/site prep.	no	6.6	50-75	4.2
	TOTALS	13 delivered	1041.4		611.3

Total Area of Ground Surveyed = 0.5 hectares

Total Length of Stream Bank Surveyed = 161 meters

Disturbed Soil per Hectare = 2082.8 m^2/hectare

Area Exposed Soil per Hectare = 1222.6 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 576.7 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 1153.4 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 576.7 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 1153.4 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
falling	2	3.3	1.6	0.3
yarding	4	30.5	16.0	2.8
yarding/falling	9	131.5	117.3	20.3
yarding/site prep.	2	87.6	83.4	14.5
shovel trail	2	358.4	358.4	62.1

NARRATIVE:

The forest practices evaluated with this survey include clearcut harvesting, primarily using ground-based equipment (shovels), along both sides of an unbuffered type 4 tributary to Gunderson Creek. As can be seen from the summary, a substantial amount of ground disturbance occurred due to tree falling and yarding within the inner gorge of the stream's valley, with fine sediment being routed to the stream from 13 of the 19 erosion features mapped. All of the features which delivered were located within 10 meters of the stream, and at least three of these features resulted in direct disturbance of the stream banks.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	7/25/95
Site Id #	O-05	Survey Id #	SR-01
Water Type	4	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no	12.0	25-50	4.5
2	yarding/falling	yes	10.5	75-100	9.2
3	yarding/falling	no	80.0	25-50	30.0
4	yarding	no	13.3	75-100	11.6
5	falling	no	4.5	0-25	0.6
6	yarding/falling	no	21.6	0-25	2.7
7	shovel trail	no	136.0	0-25	17.0
8	yarding/falling	no	2.0	50-75	1.2
9	shovel trail	yes	383.0	25-50	143.6
10	yarding/falling	yes	51.0	0-25	6.4
11	yarding	no	3.2	50-75	2.0
12	yarding/falling	yes	19.6	0-25	2.5
13	yarding/site prep.	no	222.2	0-25	27.8
14	yarding	yes	22.0	25-50	8.2
15	yarding/falling	no	8.7	0-25	1.1
16	yarding/falling	no	20.5	0-25	2.6
17	yarding/falling	no	9.9	0-25	1.2
18	falling	yes	1.8	25-50	0.7
19	yarding/site prep.	no	6.6	50-75	4.1
	TOTALS	6 delivered	1028.4		277.0

Total Area of Ground Surveyed = 0.5 hectares

Total Length of Stream Bank Surveyed = 161 meters

Disturbed Soil per Hectare = 2056.8 m^2/hectare

Area Exposed Soil per Hectare = 554.0 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 170.6 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 341.2 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 170.6 m^2.

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 341.2 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
falling	2	1.3	0.7	0.4
yarding	4	26.3	8.2	4.8
yarding/falling	9	56.9	18.1	10.6
yarding/site prep.	2	31.9	0.0	0.0
shovel trail	2	160.6	143.6	84.2

NARRATIVE:

The forest practices evaluated at this site include clearcut harvesting, primarily using ground-based equipment (shovels), along both sides of an unbuffered type 4 stream. Following the harvest, the site was prepared for planting by piling the slash using shovels, which resulted in additional soil disturbance. Even though the extent of exposed soils was reduced in 1995 due to natural revegetation, and delivery of sediment from several features had apparently ceased, sediment was still being routed to the stream from harvest-related erosion. Six of the 13 erosion features found to be delivering sediment in 1994 were continuing to deliver in 1995. All of the features which delivered sediment to the type 4 stream in 1995 were located within 10 meters of the stream channel. One shovel trail and associated yarding scars (feature 9) was found to be a source of a substantial amount of sediment deposition in the stream. This trail came down to and crossed the stream. Direct disturbance of streambanks by yarding and falling (features 2 and 14) also resulted in chronic sources of sediment. At feature 2, the eroding bank was expanding, with the area of disturbed bank being 3 times larger in 1995 than in 1994.

BMP EFFECTIVENESS CALL:

Ground-based Yarding without stream buffers: NOT EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	8/3/94
Site Id #	O-05	Survey Id #	SR-02
Water Type	4	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	yes	99.8	50-75	62.4
2	yarding	yes	639.1	75-100	559.2
3	shovel trail	yes	119.3	50-75	74.6
4	yarding	yes	182.5	0-25	22.8
5	yarding	yes	62.6	75-100	54.8
6	yarding	yes	284.4	0-25	35.6
7	yarding	yes	66.0	25-50	24.8
8	yarding	yes	32.6	50-75	20.4
	TOTALS	8 delivered	1486.3		854.6

Total Area of Ground Surveyed = 0.3 hectares

Total Length of Stream Bank Surveyed = 100 meters

Disturbed Soil per Hectare = 4954.3 m^2/hectare

Exposed Soil per Hectare = 2848.7 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 854.6 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 2848.7 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 854.6 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 2848.7 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	7	780.0	780.0	91.3
shovel trail	1	74.6	74.6	8.7

NARRATIVE:

The forest practices evaluated with this survey include clearcut harvesting, primarily using cable yarding but possibly assisted with ground-based yarding (shovels), along one side of an unbuffered type 4 stream. Seven of the eight erosion features identified were caused by cable yarding (and probably also falling) activities within and across the inner gorge area of the stream valley. Sediment from one shovel trail feature, which was located above the slope break of the inner gorge, was routed to the stream via a large yarding scar (this shovel trail may have been associated with either harvest or site preparation activities).

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	7/25/95
Site Id #	O-05	Survey Id #	SR-02
Water Type	4	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	yes	99.8	25-50	37.4
2	yarding	yes	639.1	75-100	559.2
3	shovel trail	no	119.3	50-75	74.6
4	yarding	yes	182.5	0-25	22.8
5	yarding	yes	62.6	50-75	39.1
6	yarding	yes	284.4	0-25	35.6
7	yarding	yes	66.0	50-75	41.2
8	yarding	no	32.6	0-25	4.1
	TOTALS	6 delivered	1486.3		814.0

Total Area of Ground Surveyed = 0.3 hectares

Total Length of Stream Bank Surveyed = 100 meters

Disturbed Soil per Hectare = 4954.3 m^2/hectare

Exposed Soil per Hectare = 2713.3 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 735.3 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 2451.0 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 735.3 m^2.

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 2451.0 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	7	739.4	735.3	100.0
shovel trail	1	74.6	0.0	0.0

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using cable yarding systems (possibly assisted with ground-based yarding) along an unbuffered type 4 stream. Two of the eight erosion features found to be delivering sediment to the stream in 1994 were no longer delivering in 1995; the remaining six features were still delivering sediment 19 months following the completion of harvest. All of the erosion features associated with chronic sediment delivery to the stream were caused by yarding (and possibly falling) activities within the inner gorge of the type 4 stream valley, and all of these were located within 10 meters of the stream. The survey was conducted on the west side of the stream only. The direction of yarding was across the stream valley at an oblique angle generally from east to west, leaving soils on the east side of the valley somewhat less disturbed.

BMP EFFECTIVENESS CALL:

Cable Yarding without stream buffers: NOT EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	10/10/94
Site Id #	O-05	Survey Id #	SR-03BU
Water Type	2,4	Months Since Harvest	10

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	no	19.4	50-75	12.2
2	windthrow	no	10.0	25-50	3.8
3	windthrow	no	4.3	25-50	1.7
4	windthrow	no	2.9	0-25	0.4
5	windthrow	no	2.0	0-25	0.3
6	windthrow	yes	6.0	50-75	3.8
7	windthrow	yes	3.4	25-50	1.3
8	windthrow	yes	4.8	75-100	4.2
9	windthrow	yes	43.8	75-100	38.4
10	windthrow	yes	3.0	75-100	2.7
11	windthrow	yes	5.1	75-100	4.5
12	windthrow	no	2.5	75-100	2.2
13	yarding	no	110.0	50-75	68.9
14	windthrow	no	17.9	75-100	15.7
15	windthrow	no	6.8	75-100	6.0
16	windthrow	no	21.8	75-100	19.1
17	windthrow	no	32.9	75-100	28.8
18	windthrow	no	9.5	75-100	8.3
19	windthrow	no	14.5	75-100	12.7
20	windthrow	no	13.5	25-50	5.1
21	shovel trail	no	45.0	0-25	5.7
26	shovel trail	no	88.2	50-75	55.1
27	windthrow	no	6.6	75-100	5.8
28	windthrow	no	6.7	75-100	5.9
29	windthrow	yes	21.6	75-100	18.9
30	windthrow	no	7.9	75-100	6.9
31	windthrow	no	4.9	75-100	4.3
32	windthrow	no	12.0	75-100	10.5
33	windthrow	no	4.9	75-100	4.3
34	windthrow	yes	10.5	75-100	9.2
35	yarding	no	34.0	50-75	21.3
36	shovel trail	no	46.8	0-25	5.9
37	shovel trail	no	65.1	25-50	24.5
	TOTALS	8 delivered	688.3		418.4

Total Area of Ground Surveyed = 0.8 hectares

Total Length of Stream Bank Surveyed = 221 meters

Disturbed Soil per Hectare = 860.4 m^2/hectare

Exposed Soil per Hectare = 523.0 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 83.0 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 103.8 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2.**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/hectare**

* Features which delivered to surface waters but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
windthrow	27	237.0	83.0	100
shovel trail	4	91.2	0	0
yarding	2	90.2	0	0

NARRATIVE:

The SR-03BU survey includes portions of the SR-03 survey area that drain to Gunderson Creek, which was buffered by a RMZ, and the lowermost segment of the type 4 tributary where it flows through the Gunderson Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. Forest practices evaluated with this survey were clearcut harvesting using ground-based equipment (shovels), possibly assisted by cable yarding systems, in the vicinity of a type 2 stream (Gunderson Creek) buffered with a RMZ. None of the erosion features directly attributable to current harvest practices (*e.g.*, shovel trails, yarding scars) were delivering sediment to Gunderson Creek. Substantial amounts of new windthrow occurred along the RMZ, some of which delivered sediment to the stream and resulted in a failure of the upper stream bank. Four of the windthrow features mapped (#s 2,3,4 and 5) were judged to have occurred prior to this harvest. Several new windthrow features were found to not deliver sediment to the stream, because the rootwads and divots were functioning as sediment traps, even though they were located within 10 meters of the stream bank. Of the 27 windthrow features mapped, 8 were found to have routed sediment to Gunderson Creek, and all of these were located within 10 meters of the channel.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	7/25/95
Site Id #	O-05	Survey Id #	SR-03BU
Water Type	2, 4	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
Features 1-21 & 26-37 not re-surveyed for extent of erosion					
38 (new feature)	windthrow	no	42.0	75-100	36.8
	TOTALS	0 delivered	42.0		36.8

Total Area of Ground Surveyed = Not Determined--See Narrative

Total Length of Streambank Surveyed = Not Determined--See Narrative

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2.

*Features that delivered to surface waters but were not directly attributable to current harvest practices, such as windthrow, were excluded from this calculations.

CAUSE/EFFECT INFORMATION: refer to the 1994 survey summary

NARRATIVE:

The SR-03BU survey includes portions of the SR-03 survey area that drain to Gunderson Creek, which was buffered by a RMZ, and the lowermost segment of the type 4 tributary where it flows through the Gunderson Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvesting using ground-based equipment (shovels), possibly assisted by cable yarding systems, in the vicinity of a type 2 stream (Gunderson Creek) buffered with a RMZ. Site preparation (slash piling) had been conducted using shovels. This survey was different from other follow-up surveys at this site in that the objective here was to specifically re-survey only those features which delivered to surface waters in 1994 and were directly attributable to current harvest practices, to determine whether sediment delivery continued into the second year following the harvest. Windthrow features that delivered to surface waters in 1994 were not re-surveyed to measure soil disturbance or the degree of soil exposure, nor were harvest erosion features that did not deliver to streams. Due to the objectives of this particular survey, the calculation of hectares surveyed and the associated metrics was not possible. One new feature was documented along the edge of the RMZ during the 1995 survey: a windthrow at the top of a slope break above an old railroad grade. This had resulted in a large, bare slide scarp, but was not routing sediment to surface waters. Several of the windthrow features documented in 1994 that had delivered sediment to Gunderson Creek and had fallen into the stream channel, were inspected during the 1995 survey. It was observed that the areas of exposed soil associated with upturned rootwads and stream bank failure were continuing to erode and deliver sediment in 1995, however, the trees that entered the channel were providing important beneficial water quality and fish habitat functions, including cover, pool formation (both dammed and scour pools), and sediment storage. The RMZ was effective at preventing direct sediment delivery to Gunderson Creek from harvest site erosion.

BMP EFFECTIVENESS CALL:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	10/10/94
Site Id #	O-05	Survey Id #	SR-03NB
Water Type	4	Months Since Harvest	10

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
22	shovel trail	yes	105.0	25-50	39.5
23	shovel trail	yes	53.8	25-50	20.2
24	yarding	yes	39.2	75-100	34.2
25	yarding	no	10.3	50-75	6.5
	TOTALS	3 delivered	208.3		100.4

Total Area of Ground Surveyed = 0.2 hectares

Total Length of Stream Bank Surveyed = 129 meters

Disturbed Soil per Hectare = 1041.5 m^2/hectare

Exposed Soil per Hectare = 502.0 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 93.9 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 469.5 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 93.9 m^2.

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 469.5 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
shovel trail	2	59.7	59.7	63.6
yarding	2	40.7	34.2	36.4

NARRATIVE:

The SR-03NB survey includes portions of the SR-03 survey area that drain to the un-buffered type 4 stream, which is a tributary to Gunderson Creek. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. Forest practices evaluated with this survey were clearcut harvesting using ground-based equipment (shovels), possibly assisted by cable yarding systems, in the vicinity of an un-buffered type 4 stream. All of the erosion features identified in the un-buffered portion of the survey area were directly attributable to current harvest practices, and three of the four erosion features were delivering sediment to the unbuffered type 4 stream, and were located within 10 meters of the stream.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	7/25/95
Site Id #	O-05	Survey Id #	SR-03NB
Water Type	4	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
22	shovel trail	yes	105.0	25-50	39.4
23	shovel trail	no	53.8	0-25	6.7
24	yarding	yes	39.2	75-100	34.3
25	yarding	no	not re-surveyed		
	TOTALS	2 delivered	198.0		80.4

Total Area of Ground Surveyed = Not Determined--See Narrative

Total Length of Streambank Surveyed = Not Determined--See Narrative

Total Surface Area Exposed Soil from Features which Delivered to Water = 73.7 m^2.

CAUSE/EFFECT INFORMATION (limited to the three features surveyed in 1995):

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
shovel trail	2	46.1	39.4	53.5
yarding	1	34.3	34.3	46.5

NARRATIVE:

The SR-03NB survey includes portions of the SR-03 survey area that drain to the un-buffered type 4 stream that is a tributary to Gunderson Creek. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvesting using ground-based equipment (shovels), possibly assisted by cable yarding systems, in the vicinity of an unbuffered type 4 stream. Site preparation (slash piling) had been conducted using shovels. This survey was different from other follow-up surveys at this site in that the objective here was to specifically re-survey only those features that delivered to surface waters in 1994 and were directly attributable to current harvest practices to determine whether sediment delivery continued into the second year following the harvest. Erosion features that did not deliver sediment to surface waters in 1994 were not re-surveyed to measure soil disturbance or the degree of soil exposure. Due to the objectives of this particular survey, the calculation of hectares surveyed and the associated metrics was not possible. Of the 3 features that were directly attributable to harvest activities and that delivered sediment to the un-buffered type 4 stream in 1994, 2 of them were still delivering sediment in 1995. Both of these features were located within 10 meters of the type 4 stream. One of these features was a shovel trail that crossed the stream, and the other was a yarding scar which disturbed a 15 meter section of the upper and lower stream banks, which were still mostly bare in 1995.

BMP EFFECTIVENESS CALL:

Ground-based Yarding without stream buffers: NOT EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date(s)	10/10/94
Site Id #	O-05	Survey Id #	SR-04
Water Type	2, 4, 5	Months Since Harvest	10

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	yes	5.5	50-75	3.5
2	windthrow	no	2.6	50-75	1.7
3	yarding	no	9.1	50-75	5.7
4	yarding	no	7.7	25-50	2.9
5	yarding	no	12.0	25-50	4.5
6	yarding	no	4.5	0-25	0.6
7	windthrow	no	2.9	75-100	2.5
8	yarding	yes	91.0	0-25	11.4
9	yarding	no	194.3	0-25	24.3
10	windthrow	yes	7.7	75-100	6.8
11	windthrow	yes	11.6	50-75	7.3
12	windthrow	no	3.8	50-75	2.4
	TOTALS	4 delivered	352.7		73.6

Total Area of Ground Surveyed = 1.7 hectares

Total Length of Stream Bank Surveyed = 427 meters

Disturbed Soil per Hectare = 207.5 m^2/hectare

Exposed Soil per Hectare = 43.3 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 29.0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 17.1 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 11.4 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 6.7 m^2/hectare**

*The features that delivered to surface waters but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
windthrow	6	21.7	17.6	60.7
yarding	6	49.4	11.4	39.3

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using ground-based yarding equipment (shovels) in the vicinity of a type 2 stream (Gunderson Creek) buffered with a RMZ. The survey area covered a portion of the 1-sided RMZ and the clearcut area upslope of the RMZ, and included the lowermost reaches of a type 4 tributary of Gunderson Creek and two very short type 5 tributaries that originated at springs on the stream terrace deposits. The average 1-sided RMZ width was 61 meters in the vicinity of the survey area, and in portions the RMZ extended to the upper slope break of the stream terrace. The yarding erosion features identified did not deliver sediment to Gunderson Creek, but one yarding feature was delivering to a type 5 channel that went subsurface at an old railroad grade, and apparently did not route sediment to Gunderson Creek. Windthrow was found to be a sediment source to the type 4 stream.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Gunderson Cr.	Survey Date	7/25/95
Site Id #	O-05	Survey Id #	SR-04
Water Type	2, 4	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	no	5.5	50-75	3.4
2	windthrow	no	2.6	50-75	1.6
3	yarding	no	8.0	50-75	5.0
4	yarding	no	7.7	25-50	2.9
5	yarding	no	12.0	50-75	7.5
6	yarding	no	(no longer a feature--revegetated)		
7	windthrow	no	2.9	75-100	2.5
8	yarding	no	32.6	25-50	12.2
9	yarding	no	194.2	0-25	24.2
10	windthrow	yes	7.7	75-100	6.7
11	windthrow	yes	11.6	50-75	7.3
12	windthrow	(not re-surveyed)			
13	windthrow	no	13.0	75-100	11.3
	TOTALS	2 delivered	297.8		84.6

Total Area of Ground Surveyed = 0.6 hectares

Total Length of Stream Bank Surveyed = 240 meters

Disturbed Soil per Hectare = 496.3 m^2/hectare

Exposed Soil per Hectare = 141.0 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 14.0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 23.3 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/hectare**

*The features that delivered to surface waters but were not directly attributable to current harvest practices on, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered. (m^2)	% of Total Delivery (based on area of exposed soil)
windthrow	6	32.8	14.0	100
yarding	5	51.8	0.0	0

NARRATIVE:

The forest practices evaluated were clearcut harvesting using ground-based equipment (shovels) along a type 2 stream (Gunderson Creek) buffered with a RMZ. This 1995 follow-up to the 1994 survey covered only a portion of the original survey area, including the lower portion of a type 4 tributary to Gunderson Creek; it did not cover the portion of the RMZ that included the two short type 5 tributaries. It included the area where the RMZ narrowed and where all but one of the 1994 erosion features had been mapped, hence the higher density of disturbed and exposed soil. Two of the four erosion features that were delivering sediment in 1994 were continuing to deliver in 1995, and both of these were windthrown trees along the banks of the type 4 tributary. The 1995 survey documented one new windthrow feature (#13). In 1995, none of the erosion features directly attributable to current harvest practices were delivering sediment to Gunderson Creek or the lower portion of its tributary (e.g. within the RMZ). The RMZ, which had an average 1-sided width of 61 meters in the SR-04 survey area, was effective at preventing direct sediment delivery to Gunderson Creek from harvest site erosion.

BMP EFFECTIVENESS CALL:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Gunderson Creek O-05
Treatment Survey ID#: CS-01 Water Type: 4
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: Cable and Ground-based Yarding with no Buffer

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	37	7/2/93	42	6/30/93
Post-Treatment Survey #1:	15	5/25/94	(The Control Reach was not available for follow-up control surveys as the site was harvested by an adjacent landowner in early 1994.)	
Change from Pre-Treatment Score:	-22			
Net Change (Control-Treatment):	n/a			
Post-Treatment Survey #2:	24	7/24/95		
Change from Pre-Treatment Score:	-13			
Net Change (Control-Treatment):	n/a			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:

The treatment reach has a step-pool morphology with an average channel gradient of 10%. It was noted during the initial survey that the stream channel had numerous eroding lower banks and was incising, and there was evidence that it had been used as a yarding corridor during the original logging. This is reflected in the relatively low pre-treatment score. An old road grade crossed above the reach, where the second-growth forest stand appeared to be about 25 years old. The control reach which had been paired with this treatment reach was located on an adjacent parcel that was harvested in 1994 before a follow-up survey could be conducted. (However, a general comparison can be made with results from pre-post treatment surveys in that study reach, which was used to evaluate the effectiveness of a RMZ that was established along what had been the "control" stream [see case summary for the Gunderson 2 study sit]. For two post-treatment surveys conducted on 5/24/94 and 7/24/95 in the RMZ study reach at Gunderson 2 [which had been referred to as the CS-02 control reach for Gunderson Creek study site], the channel condition scores were 41 and 44 points, respectively. If before-after results from the RMZ reach are compared to the results for this un-buffered stream, the net decrease in scores would be -21 points and -15 points for the first and second post-treatment surveys, respectively.) The 60% decrease in treatment reach score during the first year following the harvest was due to increased storage of fine sediment in pools (> 10 cm. thick), and an overall fining of the streambed in non-pool areas as well, including a shift from gravels to fines as the dominant particle size, as well as increased bed mobility and destabilization of sediment storage elements, increased bank erosion, and shifts in woody debris to predominately small-sized logging slash. It was noted during the 1994 survey that there appeared to be a two-tiered streambed, with a new layer of substrate composed of fresh fines being stored in logging slash overlaying, and in some places down-cutting to, the pre-existing channel. Shovels had been used to clear the channel and stream valley of slash which was piled, and some of the upper and lower bank disturbance may have been due to this site preparation, but much of the disturbance was attributable to falling and yarding. The 1995 score was 35% less than the pre-treatment score due to continued effects of fine sediment deposition in pools (5-10 cm. thick) and non-pool areas, bed mobility, and woody debris characteristics. It was noted in 1995 that there were several small sediment wedges forming behind small woody debris (slash) jams which did not appear stable, but that steps formed by larger-sized, old wood appeared to remain stable. Bare areas on upper banks and valley sides which were disturbed by logging were actively eroding and continued to be a source of sediment to the stream. In lieu of having a control reach, the reach immediately above the treatment reach was examined at the time of the 1995 survey as a comparison and to evaluate upstream conditions. This reach had mostly stable banks, and a substrate that was mostly dull and immobile, with gravels dominant/fines subdominant. Pools in the reach upstream of the clearcut had a moderate amount of shallow fines, and sediment storage elements (woody debris) were stable and moss covered.

Stream Bank Erosion Survey Summary

Site: Gunderson Creek O-05 — Treatment
Survey Dates: 7/93 & 8/94 — Water Type: 4
Survey #: SE-01 — Total Reach length center line: 56m
Length of left bank: 60m
Length of right bank: 61m
Total Bank length: 121m

	1993	1994
Total # eroding banks	12	14
Total length of eroding banks	33.0m	53.2m
Total area of eroding banks	31.4 sq.m.	75.8 sq.m.
% of bank length eroding:	27.3%	44.0%

Cause of Bank Erosion:	Length of Eroding Banks:	
Flowing Water	30.4m	34.5m
Falling/Yarding	0.0m	18.7m
Windthrow	2.6m	0.0m

Site: Gunderson Creek O-05 — Control
Survey Dates: 7/93 — Water Type: 3
Survey #: SE-02 — Total Reach length center line: 66m
Length of left bank: 68m
Length of right bank: 78m
Total bank length: 146m

	1993	1994
Total # eroding banks	10	n/a*
Total length of eroding banks	15.0m	n/a*
Total area of eroding banks	7.3 sq.m.	n/a*
% of bank length eroding	10.3%	n/a*

Cause of Bank Erosion:	Length of Eroding Banks	
Flowing Water	15.0m	n/a*

* Control reach was harvested before follow-up surveys could be conducted.

Forest practices evaluated at this treatment reach are a clearcut harvest using both cable and ground-based equipment. The type 4 stream was not buffered. The control for this reach was logged by the adjacent landowner beginning in 1994, which prevented the investigators from conducting a follow-up control survey. However, by way of general comparison, another study reach on the same stream at the harvest unit containing the control reach, which was buffered with a RMZ, showed a slight decrease from before to after timber harvest over the same monitoring period. Before and after harvest surveys of the treatment reach showed a 17% increase in total bank length eroding between the 1993 and 1994 surveys. The surface area of eroding banks was 2.4 times greater in 1994 following timber harvest, largely because of new upper bank erosion plus increases in the extent of lower bank erosion. Eroding banks from falling and yarding activities did not exist prior to 1994, while the 1994 survey found that 35% of the total length of eroding banks was due to falling and yarding erosion scars. Although the eroding banks were smaller features in 1993, they were more exposed (i.e. lacking vegetation or moss cover): 10% of the banks sampled were 0-25% exposed, 20% were 25-50% exposed, 30% were 50-75% exposed, and 40% were 75-100% exposed. In 1994, 24% of the eroding banks sampled were 0-25% exposed, 44% were 25-50% exposed, 21% were 50-75% exposed, and 14% were 75-100% exposed.

BMP Effectiveness Rating: NOT EFFECTIVE

Road BMP Effectiveness Summary

Study Site: O-05: Gunderson Creek - New Road Construction

BMP Effectiveness Ratings

Survey Employed	Culvert BMPs: Stream Xings (WAC 222-24-040)	Culvert BMPs: Relief (WAC 222-24-025)	Road Construction BMPs: Cutslopes (WAC 222-24-030)	Road Construction BMPs: Fillslopes (WAC 222-24-030)
Culvert Condition				
CC-01	Not Effective	Partially Effective		
Cutbank/Fillslope				
CF-01			Not Effective	Effective
CF-02			Not Effective	Effective
CF-03			Not Effective	Effective
CF-04			Indeterminate	Effective

ASPECT 1:
Effectiveness in terms of chronic erosion with delivery to surface waters.

Case Narrative: Chronic erosion of culvert fills was documented at all nine stream crossings evaluated during the 1994 surveys (19 months following road construction). Erosion of culvert fills at two of the nine had been reduced to slight levels by the second year of road life and these culvert installations were rated "effective" in consideration of the short, 2 meter fill heights which minimized chronic sediment delivery, with erosion continuing at moderate to severe levels at the remainder of crossing culverts. By the time of the last survey, 33 months following road construction, the extent of erosion on some of the culvert fills had been reduced further through natural re-vegetation, but at two of the crossings it remained at moderate to severe levels. Three of the eight relief culverts delivered to surface waters, after channels developed downslope of their outfalls for distances ranging from 13.5 to 76 meters. Other relief culverts resulted in channelized flow for distances ranging from 56 to 160 meters, but did not deliver to surface waters over the monitoring period. Chronic erosion of cutslopes and ditches (including gully erosion) with direct sediment delivery was documented, with about 60% of the road length surveyed (4 drainage segments totaling 415 meters) having cutslopes that were over 50% bare at 19 months following construction. Fillslopes did not deliver sediment, other than at the immediate area of culvert fills, except for minor amounts of delivery at one section where there was a ditch running below the short fillslope. Two of the four road drainage segments evaluated for cutslope, ditch, and fillslope delivery had short slope lengths, limiting the magnitude of sediment delivery.

ASPECT 2:
Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).

No in-stream surveys were conducted specifically to evaluate road effects.

Case Narrative: Unambiguous fresh sediment deposits in streams crossed by the road were documented during culvert condition surveys (at 8 of the 9 culvert installations), at distances ranging from 7 to 48 meters downstream of culvert outfalls, including at the confluence of Gunderson Creek and two type 5 tributaries which were crossed by the new road. Stream channels had downcut below at least three of the crossings, with channel erosion depths of up to 0.6 meter. At other crossings, culverts had been installed with outfalls hanging above the streambed.

OVERALL SITE BMP EFFECTIVENESS RATING:	NOT EFFECTIVE	PARTIALLY EFFECTIVE	NOT EFFECTIVE	EFFECTIVE	

Gunderson Creek Culvert Condition Survey Results

Site: O-05: Gunderson Creek
Culvert Condition Survey: CC-01
Survey Dates: 6/93, 5/94 & 7/95
Date of Construction: 10/92

Site BMP Effectiveness Ratings:

Stream X-ing: Not Effective
Relief: Partially Effective

Culvert # and Type	Point of Observation	Extent of Erosion Year 1993	1994	1995	Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-01 Relief	Inflow	None	Slight	None	n/a	variable	Y	slight--2+m	No	Yes
	Outflow	None	Slight	Moderate	(5m)	Increase				
C-02, T5 x-ing	Inflow	Slight	Slight	None	38m	Decrease	Y	n/a	Yes	Yes
	Outflow	Slight	Slight	Slight	(38m)	Constant				
C-03, T5 x-ing	Inflow	Slight	Slight	Slight	63m	Constant	Y	n/a	Yes	No
	Outflow	Severe	Severe	Slight	(63m)	Decrease				
C-04, Relief	Inflow	Slight	Slight	Slight	58m	Constant	Y	Yes, 26m	Yes, T-2	No
	Outflow	Slight	Moderate	Slight	(208m)	Variable				
C-05, T5 x-ing	Inflow	Moderate	Moderate	Slight	157m	Decrease	Y	n/a	Yes	No
	Outflow	Severe	Moderate	Slight	(46m)	Decrease				
C-06, T5 x-ing	Inflow	Slight	Slight	Slight	39m	Constant	Y	n/a	Yes	Yes
	Outflow	Moderate	Slight	None	(22m)	Decrease				
C-07, Relief	Inflow	Moderate	Moderate	Slight	44m	Decrease	Y	slight-2+m	No	Yes
	Outflow	Moderate	Moderate	Slight	(46m)	Decrease				
C-08, T3 x-ing	Inflow	Severe	Severe	Slight	58m	Decrease	Y	n/a	Yes	No
	Outflow	Severe	Severe	Slight	(79m)	Decrease				
C-09, Relief	Inflow	Severe	Moderate	Slight	45m	Decrease	Y	Yes, 59m	No	Yes
	Outflow	Severe	Severe	Moderate	(42m)	Decrease				
C-10, Relief	Inflow	Moderate	Moderate	Severe	42m	Increase	Y	Yes, 75m	No	Yes
	Outflow	Moderate	Moderate	Severe	(115m)	Increase				
C-11, T4 x-ing	Inflow	Severe	Severe	Severe	185m	Constant	Y	n/a	Yes	No
	Outflow	Severe	Severe	Moderate	(102m)	Decrease				
C-12, Relief	Inflow	Slight	Moderate	Moderate	64m	Increase	Y	Yes, 77m	Yes, T2	No
	Outflow	Slight	Severe	Slight	(132m)	Variable				
C-13, T5 x-ing	Inflow	Slight	Moderate	Slight	139m	Variable	Y	n/a	Yes	No
	Outflow	Slight	Moderate	Slight	(52m)	Variable				
C-14,T4 x-ing	Inflow	Moderate	Moderate	Slight	91m	Decrease	Y	n/a	Yes	No
	Outflow	Severe	Severe	Moderate	(77m)	Decrease				
C-15, Relief	Inflow	Moderate	Severe	Slight	63m	Variable	Y	Yes, 160m	No	Yes
	Outflow	Moderate	Moderate	Slight	(157m)	Decrease				
C-16, T5 x-ing	Inflow	Severe	Moderate	None	133m	Decrease	Y	n/a	Yes	No
	Outflow	Moderate	Severe	None	(139m)	Decrease				
C-17, Relief	Inflow	Moderate	Severe	Severe	136m	Increase	Y	Yes, 14m	Yes, T-5	No
	Outflow	Moderate	Moderate	Moderate	(110m)	Constant				

Gunderson Creek Culvert Condition Survey Results

Comments/Notes:

The average distance between culverts was 85 meters (278 feet) with an average road gradient of 3.5 %. Armoring for both the inflows and outflows was rated as poor for all culverts. Despite a sediment trap at the outflow, fresh sediment deposits were documented covering the channel 7.2 meters downstream of culvert 2. (C2 was rated effective because it has a short fill [2m in height], and the extent of erosion was reduced to slight levels by the second year.) Gullying and slumping of the fill was documented at culvert 3 in 1994. The outflow of C-03 was not installed at the grade of the type 5 channel, but was hanging about 1m. In 1994 and 1995 fresh sediment deposits were documented downstream of C-03 and at the confluence of the type 5 and Gunderson Creek (25m downstream of the road). A channel had formed below the relief culvert C-04, and by the time of the 1993 survey it had delivered to Gunderson Creek, 26 meters downslope. 1994 observations at culvert 5 (crossing of a type 5 seep) were very similar to culvert 3 in that the channel below the culvert was incising and fresh sediment deposits were documented at the confluence of Gunderson Creek, 47.5 meters downstream from the outflow. Culvert 6 crossed another type 5 stream in which larval frogs were observed, and was delivering sediment to the stream it crossed and to Gunderson Creek, with fresh sediment deposits noted at the confluence of this stream and Gunderson Creek (30 m downstream) in 1994. (C6 was rated effective because it has a short fill [2m in height], and the extent of erosion was reduced to slight levels by the second year.) Culvert C-07 had no channel developed beyond the slash and no delivery of sediment to surface waters. C-08 is a crossing of a type 3, which had severe erosion of the fill at both inflow and outflow in 1993 and 1994, but the fill was mostly vegetated in 1995. The location of an old railroad grade crossing downstream of C-08 was re-disturbed by the road construction, but this grade was abandoned and the crossing moved upstream. By the 1994 survey, the ditch draining to culvert 9 had eroded to a sub-surface hardpan layer. A channel had formed at the C-09 outflow which had begun routing downslope to a slash pile by the 1993 survey, and had extended down a 10 % hillslope gradient for a distance of 59 meters in both 1994 and 1995. A berm at the inflow of culvert 10 was not fully functional and was allowing high flows partially bypass the inflow at culvert 10, flow down the ditch, and contribute flow to culvert 9. C-10 channelized 75m across a 12% hillslope in both 1994 and 1995; in 1993 there was a sediment plume routing downslope via overland flow but no channel yet. Neither of the channels downslope of C-09 or C-10 reached Gunderson Creek or any of its tributaries by the time of the 1995 survey. The type 4 crossing at C-11 had severe to moderate erosion in all three survey years, including gullying and slumping (to a depth of 1-2 meters) of the large fill. One gully measured 8.7m. long and accounted for 3.3 cubic meters of sediment eroded and delivered. Amphibian egg masses were observed in a pool at the outflow to culvert 12. C-12 is a relief culvert which had no evidence of channelized flow in 1993, but by 1994 a channel had developed 77m., routing road drainage to Gunderson Creek. The channel eroded by the drainage from C-12 initially went subsurface in the fill of the old railroad grade which paralleled the RMZ along Gunderson Creek, as documented in May 1994, but in August of 1994 it was observed to have channelized and delivered sediment to Gunderson Creek. In July of 1995 it was noted that the drainage was still reaching Gunderson Creek, but it appeared that active channel erosion and sediment transport had diminished. C-13 is a crossing of a small type 5 channel which runs between two wetlands located above and below of the road. The small size of the fill limits the extent of sediment delivery from this crossing. Amphibians and aquatic insects were observed in the stream at C-13. The channel at the outflow to culvert 14 had incised 0.5 meter by the 1994 survey. A gully developed on the fill at the outflow of C-14 measured 6.3 meters long and delivered 0.9 cubic meters of sediment to the type 4 stream. The C-15 relief culvert discharge channelized twice as far as any other relief culvert at this site, and although there was no delivery to surface waters over the course of the monitoring period, there is potential delivery to Gunderson Creek if channelization continues. Drainage from C-15 flowed across a landing spur before heading down across the clearcut hillslope where it merged with a rutted shovel trail on the Gunderson Creek floodplain . Sediment from C-15 had routed 57 meters by 1993, 90 meters by 1994, and 160 meters by 1995. Slumping of the fill material with delivery to the type 5 stream was documented at culvert 16 in 1993. A channel 14m meters in length had formed at the outflow to culvert 17 by the 1994 survey date--this channel delivered sediment to a type 5/wetland at the uppermost extent of a RLTA which had been left along this stream.

The condition of 17 culverts were evaluated for three years at this site with "Extent of Erosion" calls made for the area of the inflow and outflow of each culvert. 50 % of the inflows or outflows exhibited a decrease in the extent of erosion, 18 % increased, 17 % exhibited a variable erosion trend, and 15 % of the calls remained constant from 1993 to 1995. The decrease in erosion observed by 1995 at the culvert fills was primarily due to vigorous natural revegetation, evident in the 1995 photos. However, 16 of the 17 culverts continued to erode in 1995, including 7 having moderate to severe erosion in 1995. Soil pedestals 1-2 cm in height were observed on eroding fills in 1995. 6 of the 8 relief culverts had channels eroded below their outfalls, 3 of which channelized and delivered sediment to natural streams, including Gunderson Creek, during the survey period. Relief culverts C-04, C-12, C-14, and C-15 were noted to have channelized below slash piles constructed or left below their outfalls, while the slash pile below C-07 was effective at preventing channelization.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Gunderson Cr.
Survey Id #'s	CF-01
Survey Dates	7/1/93 & 5/24/94
Water Type	3
Construction Date:	10/92
Length Road Draining to Stream	79 meters

Range Road Gradient	1-10 %
Average Road Gradient	4.8 %
Range Hillslope Gradient	8-20 %
Average Hillslope Gradient	12.4 %
Range Cutslope Gradient	20-55 deg.
Average Cutslope Gradient	39.0 deg.

	Cutslopes	Fillslopes
% Observations w/short slope height	50	50
% Observations w/med. slope height	50	50
% Observations w/high slope height	0	0

	Cutslopes 1993	Cutslopes 1994	Fillslopes 1993	Fillslopes 1994
% Observations w/0-25% exposed soil	0	0	0	0
% Observations w/26-50 % exposed soil	0	50	0	75
% Observations w/51-75 % exposed soil	0	50	75	25
% Observations w/76-100 % exposed soil	100	0	25	0
% Observations w/Evidence of Erosion	100	100	80	100
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	minor	no	no
BMP Effectiveness Rating:	**Not Effective**		**Effective**	

COMMENTS:
The erosion and sediment delivery that occurred between the completion of road completion (10/92) and the survey in July 1993, was limited to the immediate culvert fill for the fillslopes, but extended to each drainage divide for the cutslopes and ditches. Scour of the ditch by flowing water to a depth of approximately 1 meter was observed during the 1993 survey. Both the cutslope and fillslope were beginning to revegetate between the 1993 and 1994 surveys, as indicated by the changes in the percent of exposed soil, however, evidence of sediment delivery from continued erosion of the cutslope and ditch was documented in the 1994 survey also.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Gunderson Cr.
Survey Id #'s	CF-02
Survey Dates	7/1/93 & 5/24/94
Water Type	4
Construction Date:	10/92

Length Road Draining to Stream	102 meters

Range Road Gradient	3-11 %
Average Road Gradient	6.7 %
Range Hillslope Gradient	23-25 %
Average Hillslope Gradient	24 %
Range Cutslope Gradient	35-40 deg.
Average Cutslope Gradient	38.3 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	67		100	
% Observations w/med. slope height	33		0	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soil	0	0	0	0
% Observations w/26-50 % exposed soil	0	33	0	0
% Observations w/51-75 % exposed soil	0	33	33	67
% Observations w/76-100 % exposed soil	100	33	67	33
% Observations w/Evidence of Erosion	100	100	67	100
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	yes	yes

BMP Effectiveness Ratings: **Not Effective** **Effective**

COMMENTS:

The findings of this survey are very similar to those of cutbank/fillslope survey CF-01 conducted on another road drainage segment. This segment of road was crowned, with a dip at the stream crossing. Near the crossing, there were short cutslopes and ditches on both sides of the road. Substantial soil erosion and sediment delivery occurred during the first winter after construction, including cutslope sloughing, ditch gullying, and gullying of the fill material at the culvert. Partial revegetation of the cutslope, fillslope, and ditch was documented in the 1994 survey, as reflected in the percent exposed soil information provided above. Ditch and cutslope gullying was again observed in the 1994 survey, as was evidence of continued sediment delivery via the ditch draining to the type 4 stream crossing. Sediment delivery from fillslope erosion was limited to the immediate area of the fill at the culvert.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Gunderson Cr.
Survey Id #'s	CF-03
Survey Dates	7/1/93 & 5/24/94
Water Type	4
Construction Date:	10/92

Length Road Draining to Stream: 77 meters

Range Road Gradient	3-4 %
Average Road Gradient	3.5 %
Range Hillslope Gradient	12-20 %
Average Hillslope Gradient	16 %
Range Cutslope Gradient	15-22 deg.
Average Cutslope Gradient	18.5 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	100		100	
% Observations w/med. slope height	0		0	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soil	0	0	0	0
% Observations w/26-50 % exposed soil	0	0	50	50
% Observations w/51-75 % exposed soil	50	50	50	50
% Observations w/76-100 % exposed soil	50	50	0	0
% Observations w/Evidence of Erosion	100	100	50	100
Evidence of Erosion w/delivery to surface water	yes	yes	no	minor amount
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	yes	yes	yes
BMP Effectiveness Ratings:	**Not Effective**		**Effective**	

COMMENTS:
The third cutbank/fillslope survey (CF-03) conducted at this study site documented lesser amounts of sediment delivery compared to surveys CF-01 and CF-02. Several factors contributed to reducing the potential and actual erosion at this road drainage segment. The road crossed the type 4 water in an area of relatively flat topography (average hillslope gradient of 16 %), which resulted in a road section with a lower average road gradient, lower cutslope gradients, and very low cutslope and fillslope heights (1-3 meters). The primary factor that minimized soil erosion and sediment delivery is the shallow hillslope angle, which provided a favorable location for the road crossing. However, despite the short cutslopes, there was chronic sediment delivery of material eroded from cutslopes, including gully erosion. The road segment is partially insloped and partially crowned, with a ditch on both sides near the stream crossing. On one side of the stream, a short spur road diverts the fillslope/ditch drainage away from the stream. The minor amount of sediment delivery from fillslope erosion (beyond the immediate vicinity of the stream crossing culvert fill) was via the ditch that was present on the other side of the stream. The fillslope in this section is very short (about 1 meter in height), which limited the magnitude of delivered fillslope sediment to negligible levels.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Gunderson Cr.
Survey Id #'s	CF-04
Survey Dates	7/1/93 & 5/24/94
Water Type	segment drains to relief culvert with potential delivery to Gunderson Creek (type 2)
Construction Date:	10/92
Length of Road Drainage Segment	157

Range Road Gradient	0-14 %
Average Road Gradient	7.6 %
Range Hillslope Gradient	13-31 %
Average Hillslope Gradient	21.2 %
Range Cutslope Gradient	22-50 deg.
Average Cutslope Gradient	38 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	100		100	
% Observations w/med. slope height	0		0	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	40	0	25
% Observations w/26-50 % exposed soils	0	20	100	50
% Observations w/51-75 % exposed soils	80	40	0	25
% Observations w/76-100 % exposed soils	20	0	0	0
% Observations w/Evidence of Erosion	60	100	0	25
Evidence of Erosion w/delivery to surface water	no	no	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	yes	no
BMP Effectiveness Ratings:	**Indeterminate**		**Effective**	

COMMENTS:

Observations of cut and fill slope erosion in the CF-04 drainage segment at the Gunderson creek study site were similar to the three other CF surveys, with one notable exception: an increase over the monitoring period in the proportion of observation points with evidence of active erosion, which is due to disturbance of the cutslopes and fillslopes by heavy equipment during logging and slash piling operations. There was evidence of chronic erosion on the short, but erodible cutslope, with sediment routing via the ditch to the relief culvert. Relief drainage from this culvert did not deliver to streams over the monitoring period, but the drainage channelized 57 meters downslope the first year after road construction. By the second year it had channelized 90 meters and by the third year had channelized 160 meters before merging with a rutted shovel trail on the floodplain of Gunderson Creek. The extent of channel development from this drainage discharge indicates a potential for sediment delivery of eroded cutslope material if channelization continues, therefore the effectiveness rating for cutslope practices is "indeterminate". The fillslope drainage was not routed to the culvert, therefore fillslope practices are rated "effective" in spite of continued erosion.

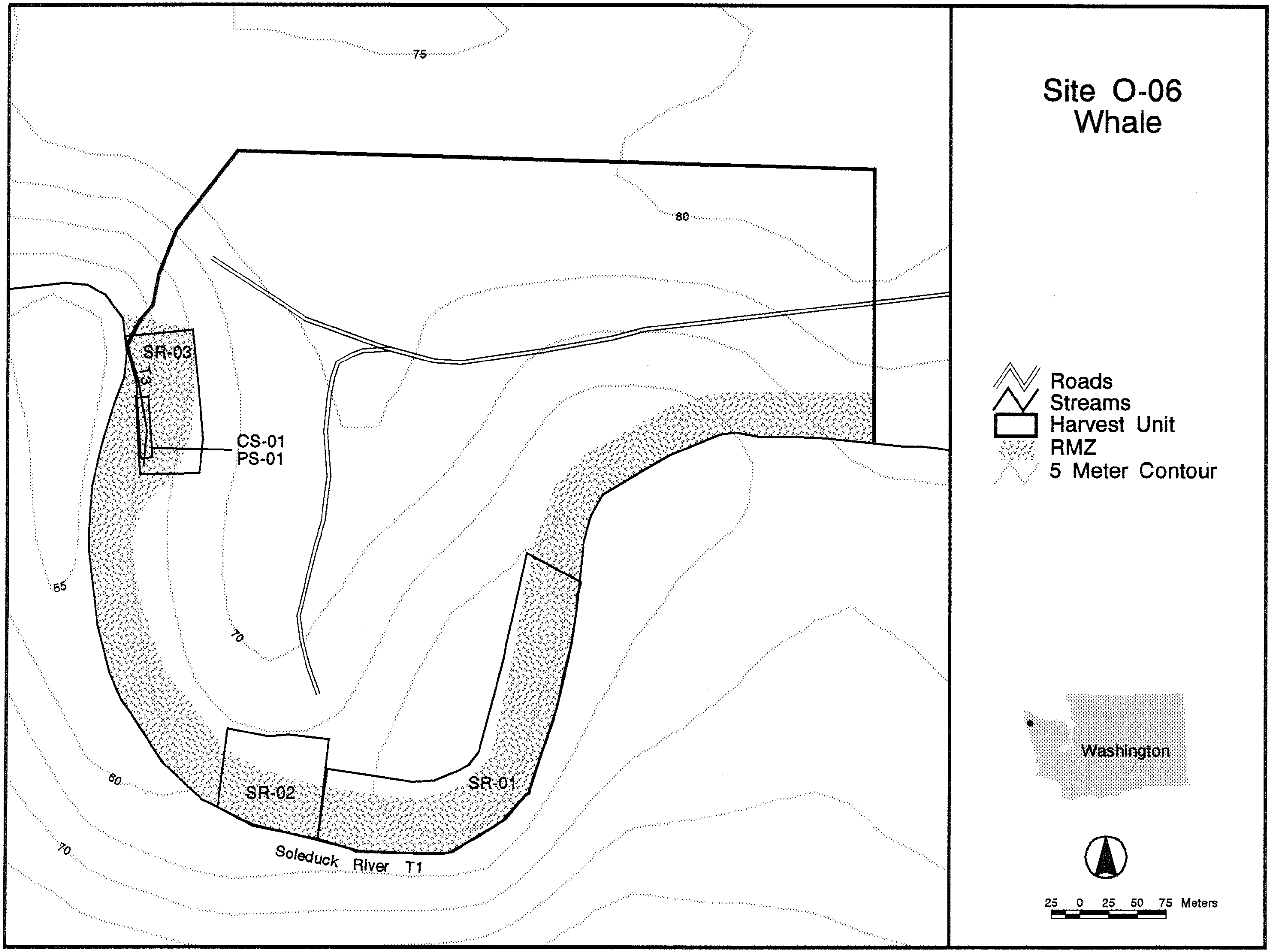
Site O-06: Whale

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, and the erosion potential hazard rating is low. The harvest BMP slope hazard category is high due to relatively steep stream valley side slopes in the survey areas, ranging from 45-55%. However, the majority of the harvest unit, outside of the RMZ, is on flat or gently-sloping ground.

The Soleduck River, Type 1+, makes a large U-shaped bend that forms the harvest unit boundary on three sides. The Soleduck River meets the Bogachiel River to form the Quillayute River, which flows into the Pacific Ocean at the town of La Push. A zero order, Type 3 stream that is a "wall-based channel" associated with the Soleduck River floodplain, 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 Type 3 stream has a plane-bed channel morphology, with an average active channel width of 1.4 meters, and an average channel gradient of 3%.

Forest practices conducted at this site include a 25 hectare clearcut with 0.4 km of new road construction. The harvest unit lies predominantly on the gentle slopes of a river terrace. The ground-based harvest was conducted using skidders and shovels. A RMZ was established along the Soleduck, with removal of trees from narrow corridors cut perpendicular to the river in portions of the RMZ. These cutting corridors stopped short of the slope break at the river bluff. The Type 3 stream flows entirely within the RMZ, which was not entered for timber harvest in the vicinity of the Type 3. The width of the RMZ averaged 30 meters and 52 meters in two survey areas along the Soleduck, and 33 meters in the survey area along the Type 3 stream. The harvest was completed in December 1993. Site preparation activities conducted concurrent with the completion of harvest included slash piling with shovel equipment.

The BMPs evaluated at the Whale site include the RMZ and ground-based harvest adjacent to the Type 3 stream and the Soleduck River. One study reach was established on the Type 3 stream for a before-after comparison of in-stream conditions; a suitable site-specific control reach was not available for this site. Channel condition surveys were conducted in July 1993, May 1994, and July 1995. Photo point surveys were conducted in July 1993 and May 1994 on the same stream reach. Sediment routing surveys were conducted in August 1994 at three different locations within the unit to evaluate harvesting in the vicinity the Type 3 stream and the Soleduck River.


Site O-06
Whale
Roads
Streams
Harvest Unit
RMZ
5 Meter Contour
Washington
25 0 25 50 75 Meters
75
80
55
70
60
70
SR-03
T3
CS-01
PS-01
SR-02
SR-01
Soleduck River T1

Harvest BMP Effectiveness Summary

Study Site:	O-06: Whale - Clearcut harvest, with RMZ						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01	Effective					
	SR-02	Effective					
	SR-03	Effective					
Case Narrative:	There was no sediment delivery to the Soleduck River or its type 3 tributary associated with logging disturbances. Soil disturbance measured 8 months following timber harvest ranged from 2-4% of the survey areas. The RMZ was not yarded across, and was not entered for harvesting in the vicinity of steeper streamside slopes. Erosion features that delivered sediment to the type 3 or the Soleduck were associated with either river bluff erosion, windthrown trees, or wildlife activities.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01	Effective					
	Photo Point:						
	PS-01	Effective					
Case Narrative:	No impacts to the type 3 "wall-based" channel were observed. It was noted that the streambed, banks, riparian vegetation, and woody debris regime remained stable throughout the monitoring period.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	The Whale	Survey Date	8/1/94
Site Id #	O-06	Survey Id #	SR-01
Water Type	1+	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no	19.2	50-75	12.0
2	yarding	no	5.5	75-100	4.8
3	shovel trail	no	192.2	25-50	72.1
4	shovel trail	no	147.6	25-50	55.4
5	yarding	no	2.2	75-100	2.0
	TOTALS	0 delivered	366.7		146.3

Total Area of Ground Surveyed = 0.8 hectares

Total Length of Stream Bank Surveyed = 133 meters

Disturbed Soil per hectare = 458.4 m^2/hectare

Exposed Soil per hectare = 182.9 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0.0 m^2

Exposed Soil from All Erosion Features that Delivered per hectare = 0.0 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per hectare = 0.0 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Yarding	3	18.8	0.0	0.0
Shovel Trail	2	127.5	0.0	0.0

NARRATIVE:
The forest practices evaluated with this survey were clearcut harvesting using ground-based equipment (shovels) in the vicinity of a type 1+ water (the Soleduck River) buffered with a RMZ. RMZ specifications met the requirements for timber harvesting along a shoreline of statewide significance (type 1+ water). During harvesting operations, the Soleduck River or the RMZ was not crossed by logging equipment or yarding operations, which helped to maintain the integrity of the riparian area including the upper and lower stream banks. Trees were harvested from the RMZ in narrow logging corridors cut in from the clearcut, but these logging areas stopped short of the river bluff. None of the harvest erosion features identified in the survey delivered sediment to streams. The RMZ, which had an average width of 30 meters in the vicinity of the SR-01 survey area, was effective at preventing sediment delivery to the river.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	The Whale	Survey Date	8/1/94
Site Id #	O-06	Survey Id #	SR-02
Water Type	1 +	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	shovel trail	no	16.0	0-25	2.0
2	windthrow	no	3.3	75-100	2.9
3	bluff erosion	yes	45.6	25-50	17.1
4	windthrow	no	3.2	75-100	2.8
5	shovel trail	no	104.0	25-50	39.0
6	bluff erosion	yes	132.0	50-75	82.5
7	windthrow	no	4.0	75-100	3.5
8	windthrow	no	5.5	75-100	4.8
9	windthrow	no	6.0	75-100	5.3
10	windthrow	no	12.5	75-100	11.0
11	windthrow	yes	18.0	0-25	2.3
12	windthrow	yes	26.1	0-25	3.3
13	windthrow	no	4.3	75-100	3.8
14	windthrow	yes	17.7	0-25	2.2
15	wildlife	yes	3.0	25-50	1.1
16	windthrow	no	11.0	75-100	9.7
17	windthrow	no	5.0	75-100	4.4
18	shovel trail	no	80.0	75-100	70.0
19	bluff erosion	yes	180.0	50-75	112.5
20	windthrow	no	2.0	75-100	1.8
	TOTALS	7 delivered	679.2		382.0

Total Area of Ground Surveyed = 3.0 hectares

Total Length of Stream Bank Surveyed = 462 meters

Disturbed Soil per Hectare = 226.4 m^2/hectare

Exposed Soil per Hectare = 127.3 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 221.0 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 73.7 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2.**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/hectare**

*Features that delivered to surface waters but are not directly attributable to timber harvest activities, such as windthrow, wildlife activity, and natural bluff river erosion, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Shovel Trails	3	111.0	0.0	0.0
Bluff Erosion	3	212.1	212.1	96.0
Wildlife	1	1.1	1.1	0.5
Windthrow	13	57.8	7.8	3.5

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using ground-based yarding equipment (shovels) along a type 1+ water (the Soleduck River) buffered with an RMZ. RMZ specifications met the requirements for timber harvesting along a shoreline of statewide significance (type 1+ water). The Soleduck River or the RMZ were not crossed by logging equipment or yarding operations during harvesting. Trees were harvested from the RMZ in narrow logging corridors cut in from the clearcut, but these logging areas stopped short of the river bluff. None of the harvest erosion features identified in the survey delivered sediment to streams. The RMZ, which had an average width of 52 meters in the vicinity of the SR-02 survey area, was effective at preventing sediment delivery to the river from harvest site erosion. The primary sediment source identified in the survey was natural erosion of the steep river bluffs along a bend in the river. Three of the 13 windthrow features identified delivered sediment to the river, but the extent of erosion and sediment delivery was minor.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	The Whale	Survey Date(s)	8/1 & 8/3 1994
Site Id #	O-06	Survey Id #	SR-03
Water Type	3	Months Since Harvest	8

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2.)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	shovel trail	no	240.0	25-50	90.0
2	windthrow	no	3.6	25-50	1.4
3	yarding	no	3.5	0-25	0.5
4	windthrow	no	9.5	75-100	8.3
5	windthrow	yes	1.5	75-100	1.3
6	yarding	no	5.8	75-100	5.1
7	falling	no	3.9	75-100	3.4
8	yarding	no	12.5	75-100	11.0
9	windthrow	no	14.8	75-100	13.0
10	windthrow	no	11.8	75-100	10.4
11	windthrow	no	2.0	75-100	1.8
12	windthrow	no	7.2	75-100	6.3
13	wildlife burrows	yes	36.0	0-25	4.5
14	wildlife trail	yes	0.5 meters wide length not measured	not recorded	n/a
	TOTALS	3 delivered	352.1		157.0

Total Area of Ground Surveyed = 1.2 hectares

Total Length of Stream Bank Surveyed = 194 meters

Disturbed Soil per Hectare = 293.4 m^2/hectare

Exposed Soil per Hectare = 130.8 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 5.8 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 4.8 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/hectare**

*Features that delivered to surface waters but are not directly attributable to timber harvest activities, such as windthrow and wildlife activity, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Shovel Trail	1	90.0	0	0
Yarding	3	16.6	0	0
Falling	1	3.4	0	0
Wildlife Activity	2	4.5	4.5	77.6
Windthrow	7	42.5	1.3	22.4

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using ground-based yarding equipment (shovels) on one side of a type 3 water buffered by a RMZ. The type 3 stream, which is a tributary of the Soleduck River, is a wall-based channel associated with the river's floodplain and originating at a spring on the valley wall. The BMPs employed, including a no-cut RMZ along the type 3 stream, were effective at preventing sediment delivery from harvest site erosion. The average width of the RMZ was 33 meters on the harvest side of the stream in the vicinity of the SR-03 survey area. On the other side of the stream was the undisturbed floodplain of the Soleduck River. A minor amount of sediment delivery was observed, associated with erosion from wildlife activity and a windthrown tree.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Whale O-06

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: none

BMP(s) Evaluated: Ground-based Harvest (Clear Cut) with RMZ

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	57	7/22/93	(No site-specific control reach available for the Whale site.)	
Post-Treatment Survey #1:	53	5/25/94		
Change from Pre-Treatment Score:	-4			
Net Change (Control-Treatment):	n/a			
Post-Treatment Survey #2:	54	7/26/95		
Change from Pre-Treatment Score:	-3			
Net Change (Control-Treatment):	n/a			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
This study reach is on a wall-based channel. The stream bed and banks were noted as being very stable during all three surveys, with lush vegetation along stream banks. Substrate in this relatively low gradient (3%) stream is dominated by fines (sand) and woody detritus. The slight decrease in channel condition score is attributable to the greater proportion of fines noted in later surveys. There was no direct disturbances of the stream from harvest activities. Within the vicinity of the study reach, the RMZ was noted to be "no-entry", and was 33 meters wide on the harvest side of the study reach. The harvest area began on flat ground at the slope break above a moderately steep valley wall. The unharvested floodplain of the Soleduck River is on the other side of the study stream. Minor erosion was noted at one location within the study reach where a log apparently rolled down the valley wall into the RMZ. A large, downed old growth cedar (referred to as "the Whale" because of its size) spanning the study reach was originally marked for salvage, but was not disturbed during logging.

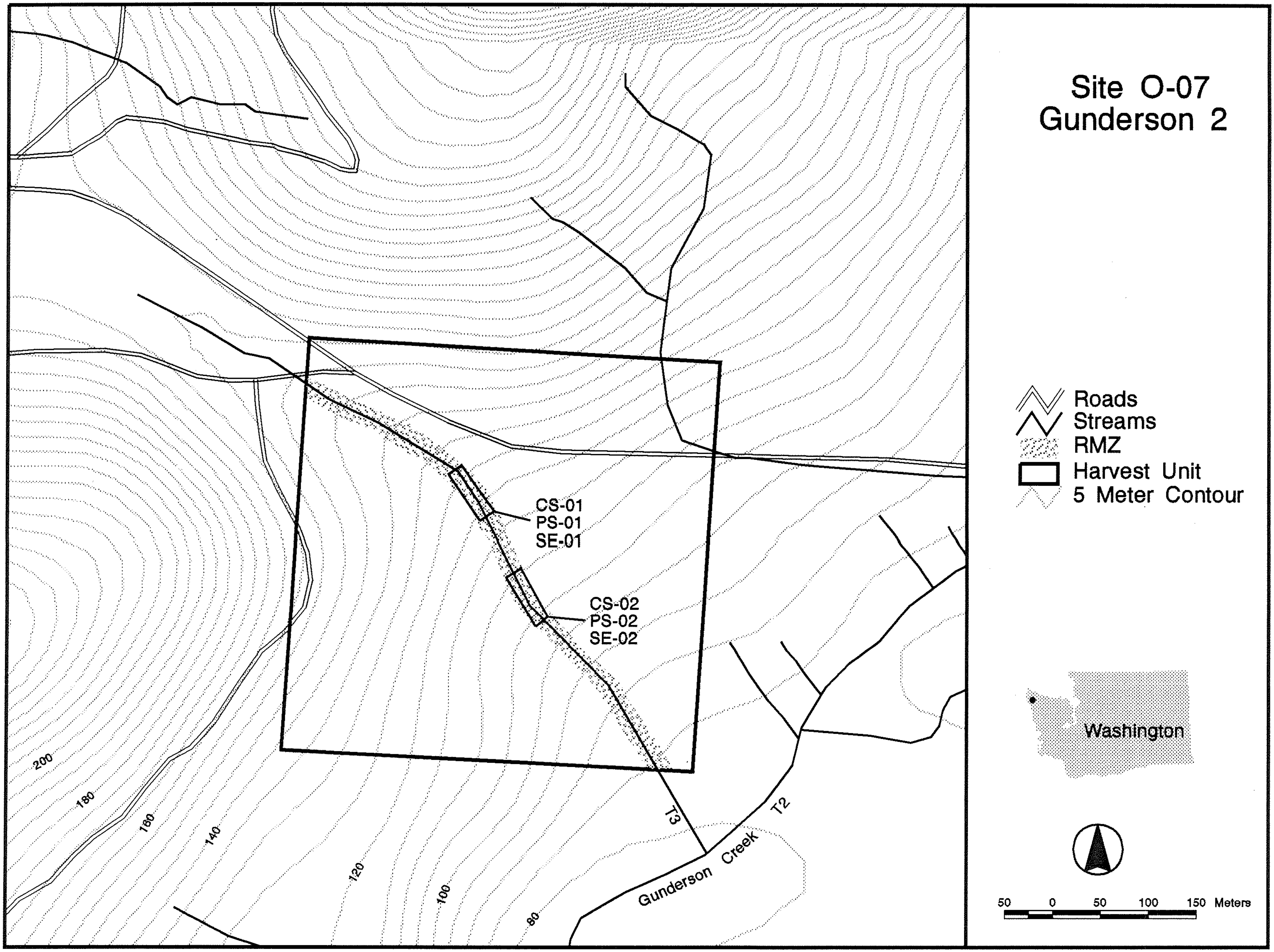
Site O-07: Gunderson 2

The Gunderson 2 site is a harvest practice study site on lands adjacent to the Gunderson Creek study site 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. The 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 BMP slope hazard category is high due to steep inner gorges along the stream.

Within the harvest unit is a zero order Type 3 stream that is a tributary of Gunderson Creek in the Soleduck River basin. This study stream has a step-pool channel morphology, with a V-shaped valley form. The average active channel width is about 3 meters, with average channel gradients of 7% and 11% in two study reaches. Originally, this stream had been surveyed to serve as a control stream for treatment reaches at the Gunderson Creek study site, but the area of the control reaches was harvested before the completion of the study, so the study reaches were used to evaluate harvest practices at the Gunderson 2 site.

Forest practices conducted at Gunderson 2 include a 13 hectare clearcut with a RMZ established along the Type 3 study stream. Ground-based yarding practices were used on the northern portion of the unit, and cable yarding was used on the remainder of the unit. Harvest of the unit was completed in July of 1994, although areas adjacent to the RMZ study reaches were completed by May 1994.

The harvest BMPs evaluated at this site include the RMZ and ground-based and cable yarding in the vicinity of the Type 3 stream which traverses the harvest unit. Two study reaches were established on the Type 3 stream. In-stream effects were evaluated using a before-after comparison approach, as there is no site-specific control stream. Channel condition and photo point surveys were conducted on both study reaches in June and July of 1993, May 1994, and July 1995. Stream bank erosion surveys were conducted on both study reaches in July 1993, with a follow-up survey at the downstream reach in October 1994.



Site O-07
Gunderson 2
Roads
Streams
RMZ
Harvest Unit
5 Meter Contour
CS-01
PS-01
SE-01
CS-02
PS-02
SE-02
T3
T2
Gunderson Creek
200
180
160
140
120
100
80
Washington
50 0 50 100 150 Meters

Harvest BMP Effectiveness Summary

Study Site: O-07: Gunderson 2 - Clearcut harvest with RMZ

	Survey Employed	**BMP Effectiveness Ratings** Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050) Ground-based Yarding WAC 222-30-070	Harvest w/ RMZ & Streambank Integrity BMPs Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters) Ground-based Yarding WAC 222-30-070	Harvest with no buffers (Type 4 and/or 5 Waters) Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) Ground-based Yarding WAC 222-30-070	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	While no sediment routing or other delivery surveys were conducted to evaluate this harvest practice, it was noted during in-stream surveys that there was no sediment delivery within the RMZ reaches evaluated that was directly attributable to timber falling or yarding or due to site preparation. Windthrow which occurred following the harvest was a source of sediment and channel disturbance, but this also contributed beneficial woody debris to the stream. Fine sediment was observed routing through the study reaches both before and after the harvest, and this is most likely attributable to the mainline haul road located upstream of the study reaches, which traverses the northern part of the subject harvest unit.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01	Effective	Effective				
	CS-02	Effective	Effective				
	Photo Point:						
	PS-01	Effective	Effective				
	PS-02	Effective	Effective				
	Stream Bank Erosion:						
	SE-02	Effective	Effective				
Case Narrative:	Channel condition surveys conducted immediately following timber cutting documented upper bank disturbance caused by recent windthrow, increased streambed mobility, and increased fines in pools, reflected in an initial decrease in channel condition scores followed by scores that were higher than pre-treatment conditions one year after the harvest. Photo point surveys documented the disturbance associated with windthrow and streambed mobility, as well as revegetation of channel margin areas in the second follow-up surveys one year after the harvest. At least 12 new windthrown trees were observed crossing the channel over 132 meters of stream surveyed during the 2 year monitoring period. Stream bank erosion surveys revealed that the surface area of eroding stream banks increased due to windthrow disturbance of upper banks, but the length of actively eroding banks decreased slightly over the study period.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE	EFFECTIVE				

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Gunderson 2: O-07

Treatment Survey ID#: CS-01 & CS-02 Water Type: 3
Control Survey ID#: None

BMP(s) Evaluated: RMZ (Cable and Ground-based Yarding)

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-01	CS-02			
Pre-Treatment Surveys:	42	44	6/30/93	n/a	
Post-Treatment Survey #1:	41	36	5/24/94	(No site-specific Control Reach was available for this site.)	
Change from Pre-Treatment Score:	-1	-8			
Net Change (Control-Treatment):	n/a				
Post-Treatment Survey #2:	44	56	7/24/95		
Change from Pre-Treatment Score:	+2	+12			
Net Change (Control-Treatment):	n/a				

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:

The CS-01 and CS-02 treatment reaches have a step-pool morphology with average channel gradients of 11% and 7%, respectively. Salmonids were observed in both reaches, and stream amphibians were observed in the uppermost reach. It was noted during the initial survey that there was evidence that the stream had been used as a yarding corridor during the original logging. This is reflected in relatively low pre-treatment scores. The CS-01 reach on this study stream was originally surveyed as the control reach for in-stream surveys at the adjacent Gunderson Creek study site, but after the site was harvested in 1994 and it was decided to use before/after evaluations to assess the RMZ at the new harvest site. Scores decreased by 2% and 18%, in the CS-01 and CS-02 reaches, respectively, during the first year following the harvest. The decrease in score on the downstream, CS-02 reach was attributable to upper bank disturbance and flow deflection onto banks, increased fines in pools, and destabilization of sediment storage elements. Much of the disturbance was due to recent windthrow. It was also noted that much of the substrate was mobile. The 1995 scores were higher than pretreatment. It was noted that there was no yarding across the stream valley, and the RMZ extended to the slope break of the inner gorge in most areas. There was no evidence of direct sediment delivery from tree falling or yarding activities. Windthrow was extensive, but some windthrow erosion scars from the previous year were beginning to re-vegetate. Other than the effects of windthrow, which is likely related to the clearcut harvest, the RMZ was effective in preventing sediment-related impacts in the stream. A mainline road which crosses above both study reaches was noted as a probable source of fine sediment in all three survey years.

Stream Bank Erosion Survey Summary

Site: Gunderson 2 O-07	Treatment			Site: Gunderson 2 O-07	Control		
Survey dates: 7/93 & 10/94	Water Type: 3			Survey Dates: 7/93	Water Type: 3		
Survey #: SE-02	Total reach length center line: 66m			Survey #: SE-01	Total Reach length center line: 66m		
	Length of left bank: 71m				Length of left bank: 68m		
	Length of right bank: 70m				Length of right bank: 78m		
	Total Bank length: 141m				Total bank length: 146m		
		Year				Year	
		1993	1994			1993	1994
Total # eroding banks		11	8	Total # eroding banks		10	n/a*
Total length of eroding banks		33.0m	30.9m	Total length of eroding banks		15.0m	n/a*
Total area of eroding banks		19.9 sq.m.	29.9 sq.m.	Total area of eroding banks		7.3 sq.m.	n/a*
% of bank length eroding:		23.4%	21.9%	% of bank length eroding		10.3%	n/a*
Cause of Bank Erosion:		Length of Eroding Banks		Cause of Bank Erosion		Length of Eroding Banks	
Flowing water		33.0m	24.4m	Flowing Water		15.0m	n/a*
Windthrow *		0.0m	6.5m				

* Control reach was harvested before follow-up surveys could be conducted.

Forest practices evaluated at the treatment reach are clearcut harvest using primarily cable yarding assisted with ground-based equipment, with an RMZ left along the type 3 stream. The control for this reach was logged, so no follow-up streambank erosion survey was conducted for the control reach. Before and after surveys of the treatment reach show a slight decrease in total length of eroding streambank between the 1993 and 1994 surveys. Although the total length of bank eroding declined, the amount of eroding bank attributed to windthrow increased by 6.5 meters between 1993 and 1994. While the length of actively eroding banks declined, the surface area of bank erosion increased by 50% following the harvest, primarily due to one large windthrow feature affecting both upper and lower banks, which accounted for 22.3 square meters of bank erosion. 5 of the 11 banks sampled in 1993 were no longer considered eroding bank features in 1994 because they were mostly re-vegetated or were below the minimum size criteria for sampling, while two new eroding banks were present in 1994. In 1993, 36% of the banks sampled were 25-50% exposed, 28% were 50-75% exposed, and 36% were 75-100% exposed soil. In 1994, 38% of the eroding banks were 0-25% exposed, 25% were 25-50% exposed, 25% were 50-75% exposed, and 12% were 75-100% exposed.

BMP Effectiveness Rating: EFFECTIVE

Willapa Hills Physiographic Region

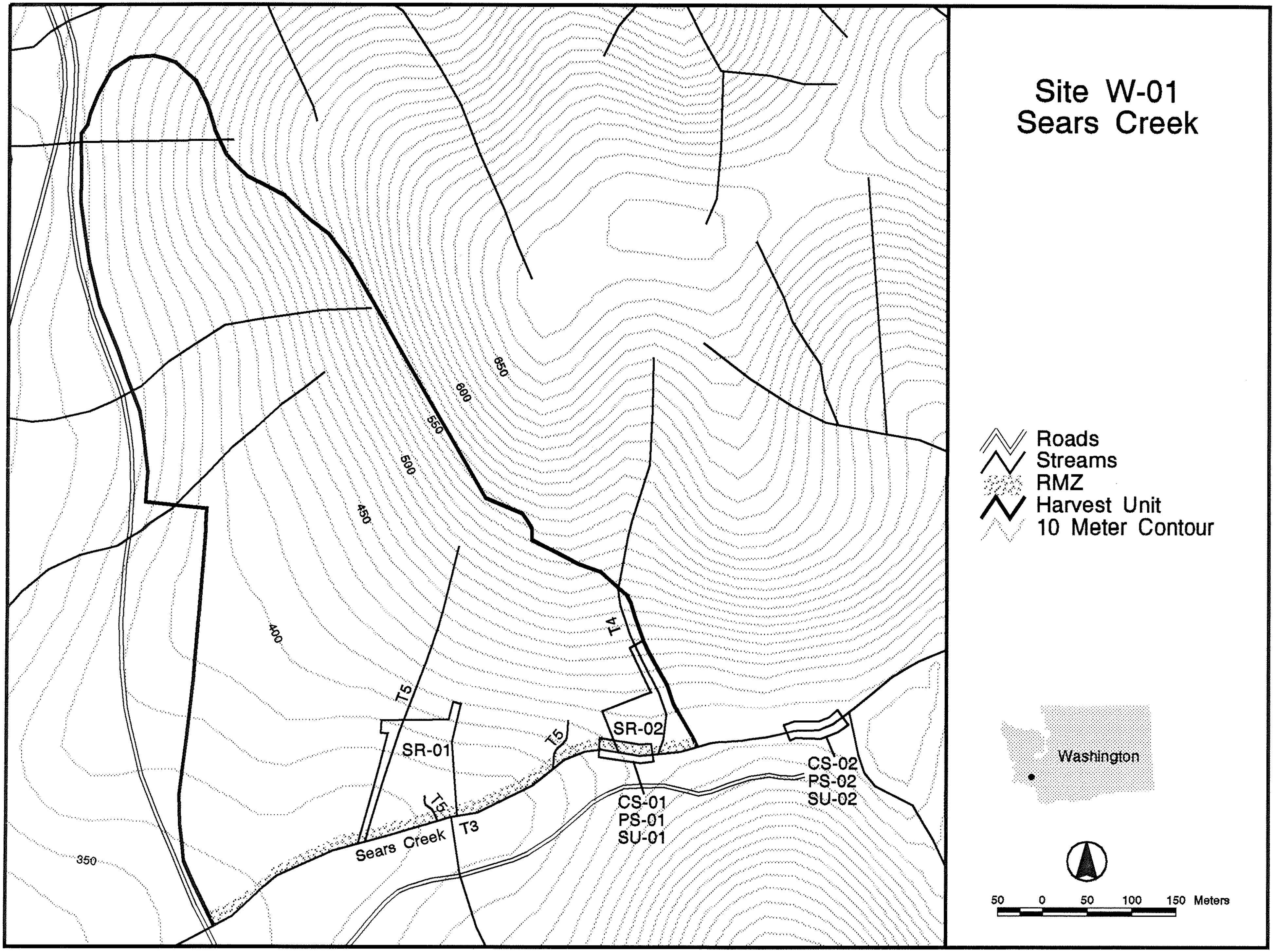
Site W-01: Sears Creek

The Sears Creek site is a harvest practice located in the southwestern corner of Lewis County about a mile 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 in the portion of the harvest unit evaluated are classified as Melbourne loam, 8-15% slopes. This soil type has a disturbed slope stability rating of stable, and a moderate hazard a rating for cutbank/fill/sidecast road construction. Erosion potential for the soil is rated as medium. The harvest BMP slope hazard category for the site is moderate, with stream valley slope gradients less than 40%.

Sears Creek, a 2nd order Type 3 tributary to the South Fork Chehalis River, flows along the southern boundary of the harvest unit. Sears Creek has a pool-riffle channel morphology in a U-shaped valley. Active channel width is 3.3 meters, with an average stream channel gradient of 2%. An unbuffered Type 4 tributary to Sears Creek and two short unbuffered Type 5 tributaries are located within the portion of the harvest unit evaluated.

Forest practices conducted at this site include a 28 hectare clearcut harvest using ground-based as well as cable yarding methods. A RMZ was established along Sears Creek, with adjacent areas harvested using rubber-tired and tracked skidders, except for the southeast corner of the unit which was cable-yarded. The width of the RMZ averaged 14 meters in the survey area evaluating ground-based harvest practices, and 16 meters in the cable-yarding survey area. The harvest was completed in February of 1994.

BMPs evaluated at this study site include the RMZ and adjacent ground-based and cable harvesting, as well as ground-based and cable harvesting in the vicinity of type 4 and 5 streams without stream buffers. Two study reaches have been established along Sears Creek. The treatment reach was established within the RMZ, and a control reach was established upstream of the harvest unit boundary. Surveys conducted on the Sears Creek study reaches include channel condition and photo point surveys conducted in April 1993 and July 1994. Channel substrate transect surveys were conducted on the same reaches in April 1993 and October 1994. Sediment routing surveys were conducted on both ground-based and cable-yarding areas of the harvest unit in August 1994 and July 1995. The sediment routing survey areas included portions of the RMZ along Sears Creek and adjacent harvest areas in the vicinity of un-buffered Type 4 and 5 streams. Estimates of the volume of sediment eroded and delivered to streams was made for selected erosion features identified during the 1995 sediment routing surveys.



Site W-01
Sears Creek
Roads
Streams
RMZ
Harvest Unit
10 Meter Contour
Washington
50 0 50 100 150 Meters
650
600
550
500
450
400
350
T4
T5
T5
T5
T3
SR-01
SR-02
Sears Creek
CS-01
PS-01
SU-01
CS-02
PS-02
SU-02

Harvest BMP Effectiveness Summary

Study Site: W-01: Sears Creek - Clearcut harvest with RMZ and harvest without stream buffers.

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing						
	SR-01BU	Effective					
	SR-01NB			Not Effective			
	SR-02BU		Effective				
	SR-02NB				Not Effective		

Case Narrative: The BMPs applied at this site for harvest with RMZ were effective at preventing direct sediment delivery to the Type 3 stream. The RMZ was not entered by heavy equipment in the survey areas. There was substantial chronic sediment delivery to and disturbance of the Type 4 and 5 tributaries to Sears Creek due to timber falling/yarding activities. Indirect sediment delivery to Sears Creek was observed, via the Type 4 tributary. In addition, the physical integrity of aquatic habitat within the Type 4 and 5 streams was degraded by direct disturbance from yarding as well as sediment deposition.

	Survey Employed	Harvest w/ RMZ: Ground-based Yarding	Harvest w/ RMZ: Cable Yarding	No buffers: Ground-based Yarding	No buffers: Cable Yarding	RLTAs: Ground-based Yarding	RLTAs: Cable Yarding
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition						
	CS-01/CS-02		Effective				
	Photo Point						
	PS-01/PS-02		Effective				
	Substrate Transects						
	SU-01/SU-02		Indeterminate				

Case Narrative: No adverse changes were noted in the RMZ treatment reach from the CS or PS surveys. No new windthrow was observed in the RMZ study reach. The SU survey results are indicative of a slight increase in fines in the treatment reach relative to the control, but the results are inconclusive. Residual effects from logging of the original forest were evident in both treatment and control reaches; there were cull logs within and adjacent to the channel, which had apparently been formerly used as a yarding corridor. Disturbance of stream banks by wildlife was also noted in both study reaches. In-stream surveys were not conducted on the Type 4 and 5 tributaries, other than assessments of chronic sediment delivery, in-stream sediment deposition, and physical stream channel disturbance made during sediment routing surveys.

		Harvest w/ RMZ: Ground-based Yarding	Harvest w/ RMZ: Cable Yarding	No buffers: Ground-based Yarding	No buffers: Cable Yarding	RLTAs: Ground-based Yarding	RLTAs: Cable Yarding
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE	EFFECTIVE	NOT EFFECTIVE	NOT EFFECTIVE		

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	8/10/94
Site Id #	W-01	Survey Id #	SR-01BU
Water Type	3, 5	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	207.0	0-25	25.9
2	skid trail	no	218.4	50-75	136.5
9	yarding	no	4.8	50-75	3.0
10	wildlife trail	yes	7.3	25-50	2.7
	TOTALS	1 delivered	437.5		168.1

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 217 meters

Disturbed Soil per Hectare = 1093.8 m^2/ha.

Area Exposed Soil per Hectare = 420.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 2.7 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 6.8 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* The features that delivered to water but were not directly attributable to harvest activities, such as wildlife trails, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	2	162.4	0.0	0
Yarding	1	3.0	0.0	0
Wildlife	1	2.7	2.7	100

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Sears Creek, which was buffered by a RMZ, and the lowermost segment of the main type 5 tributary and a short type 5 channel where they flow through the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were clearcut harvest using ground-based yarding in the vicinity of a type 3 water (Sears Creek) buffered by a RMZ. The RMZ established on Sears Creek, which averaged 14 meters in width in the vicinity of the SR-01 survey area, was effective at preventing sediment delivery to Sears Creek from harvest site erosion. There was a very slight amount of sediment delivery from a wildlife trail.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	7/19/95
Site Id #	W-01	Survey Id #	SR-01BU
Water Type	3, 5	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no longer eroding - revegetated			
2	skid trail	no	218.4	0-25	27.3
9	yarding	no longer eroding - revegetated			
10	wildlife trail	not re-surveyed			
	TOTALS	0 delivered	218.4		27.3

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 217 meters

Disturbed Soil per Hectare = 546.0 m^2/ha.

Area Exposed Soil per Hectare = 68.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* The features that delivered to water but were not directly attributable to harvest activities, such as wildlife trails, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	1	27.3	0.0	0

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Sears Creek, which was buffered by a RMZ, and the lowermost segment of the main type 5 tributary and a short type 5 channel where they flow through the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were clearcut harvest using ground-based yarding in the vicinity of a type 3 water (Sears Creek) buffered by a RMZ. The RMZ established on Sears Creek, which averaged 14 meters in width in the vicinity of the SR-01 survey area, continued to be effective at preventing direct sediment delivery to Sears Creek from harvest site erosion. Sediment delivery to Sears Creek via the un-buffered type 5 tributary is likely. Two of the four erosion features identified in the 1994 survey had revegetated to the point that they were no longer considered to be actively eroding. A wildlife trail (feature 10) was not re-surveyed, since the objective of this follow-up survey was to evaluate sediment delivery from harvest site erosion.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	8/10/94
Site Id #	W-01	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
3	skid trail	yes	18.9	0-25	2.4
4	yarding	yes	1.5	50-75	0.9
5	skid trail	yes	376.0	75-100	329.0
6	yarding	yes	13.5	50-75	8.4
7	yarding	yes	6.6	25-50	2.5
8	yarding	yes	7.0	75-50	6.1
	TOTALS	6 delivered	423.5		349.3

Total Area of Ground Surveyed = 0.3 hectares

Total Length of Stream Bank Surveyed = 237 meters

Disturbed Soil per Hectare = 1411.7 m^2/ha.

Area Exposed Soil per Hectare = 1164.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 349.3 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 1164.3 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 349.3 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 1164.3 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	2	331.4	331.4	94.9
Yarding	4	17.9	17.9	5.1

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the main un-buffered type 5 stream and a short type 5 channel upstream of where they enter the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were clearcut harvest using ground-based yarding in the vicinity of un-buffered type 5 waters. Ground-based (skidder) harvesting along and across the main un-buffered type 5 tributary to Sears creek resulted in erosion features that delivered substantial amounts of fine sediment to the stream. This included skid trail crossings and erosion caused by yarding across or within the stream channel. Stream banks within the type 5 were destabilized by yarding disturbance. All of the erosion features identified in the survey delivered sediment to streams, including the short type 5 that originated at a seep/spring just upslope of the RMZ, and all the erosion features were located within 10 meters of the streams.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	7/19/95
Site Id #	W-01	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
3	skid trail	no	6.0	25-50	2.3
4	yarding	no longer eroding - revegetated			
5	skid trail	yes	376.0	25-50	141.0
6	yarding	no longer eroding - revegetated			
7	yarding	no longer eroding - revegetated			
8	yarding	no longer eroding - revegetated			
	TOTALS	1 delivered	382.0		143.3

Total Area of Ground Surveyed = 0.3 hectares

Total Length of Stream Bank Surveyed = 237 meters

Disturbed Soil per Hectare = 1273.3 m^2/ha.

Area Exposed Soil per Hectare = 477.7 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 141.0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 470.0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 141.0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 470.0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	2	143.3	141.0	100

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the main un-buffered type 5 stream and a short type 5 channel upstream of where they enter the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were clearcut harvest using ground-based yarding in the vicinity of un-buffered type 5 waters. Chronic sediment delivery was associated with the major skid trail crossing (feature 5) of the main un-buffered type 5 tributary to Sears Creek. Sediment delivery from this feature was continuing where gully erosion had routed sediment from the skid trail to the stream. The skid trail was not water-barred or grass-seeded, although some natural revegetation had occurred since the 1994 survey. Another skid trail feature that was delivering to the other type 5 had revegetated within the seep/wetland area of the crossing, but exposed soil remained upslope of the crossing area. The yarding features identified in 1994 had revegetated to the point that they were either no longer visible or did not meet the minimum size criteria for erosion features.

BMP EFFECTIVENESS RATING:

Ground-Based Yarding without Stream Buffers: NOT EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	8/10/94
Site Id #	W-01	Survey Id #	SR-02BU
Water Type	3, 4	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding/wildlife	yes	3.0	25-50	1.1
	TOTALS	1 delivered	3.0		1.1

Total Area of Ground Surveyed = 0.2 hectares

Total Length of Stream Bank Surveyed = 111 meters

Disturbed Soil per Hectare = 13.0 m^2/ha.

Area Exposed Soil per Hectare = 5.5 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 1.1 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 5.5 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 1.1 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 5.5 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding/wildlife	1	1.1	1.1	100

NARRATIVE:

The SR-02BU survey includes portions of the SR-02 survey area that drain to Sears Creek, which was buffered by a RMZ, and the lowermost segment of the type 4 tributary where it flows through the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvest using cable yarding systems in the vicinity of a type 3 water (Sears Creek) buffered by a RMZ. Average width of the RMZ in the vicinity of the SR-02 survey (the cable yarding portion of the unit) was 16 meters. The RMZ and the harvest BMPs employed, (no yarding activity within the RMZ) were effective at preventing sediment delivery to Sears Creek, except in one instance where soil disturbance from yarding was routed to the stream via a wildlife trail. Good suspension of logs was achieved on the lower hillslopes closest to the RMZ, leaving relatively little soil disturbance in the RMZ survey area.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	7/11/95
Site Id #	W-01	Survey Id #	SR-02BU
Water Type	3, 4	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding/wildlife	no longer eroding - revegetated			
	TOTALS	0 delivered	0.0		0.0

Total Area of Ground Surveyed = 0.2 hectares

Total Length of Stream Bank Surveyed = 111 meters

Disturbed Soil per Hectare = 0 m^2/ha.

Area Exposed Soil per Hectare = 0 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

NARRATIVE:

The SR-02BU survey includes portions of the SR-02 survey area that drain to Sears Creek, which was buffered by a RMZ, and the lowermost segment of the type 4 tributary where it flows through the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvest using cable yarding systems in the vicinity of a type 3 water (Sears Creek) buffered by a RMZ. Average width of the RMZ in the vicinity of the SR-02 survey (the cable yarding portion of the unit) was 16 meters. The RMZ and the harvest BMPs employed, (no tree harvesting or yarding activity within the RMZ) were effective at preventing chronic sediment delivery directly to Sears Creek from harvest site erosion. However, chronic sediment delivery to Sears Creek occurred via the un-buffered type 4 tributary evaluated in the SR-02NB survey. Good suspension of logs was achieved on the lower hillslopes closest to the RMZ, leaving relatively little soil disturbance in the RMZ survey area. The only erosion feature identified in the 1994 survey had revegetated by the time of the follow-up survey.

BMP EFFECTIVENESS RATING:

RMZ (Cable Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	8/10/94
Site Id #	W-01	Survey Id #	SR-02NB
Water Type	4	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
2	yarding	no	9.2	25-50	1.2
3	falling	yes	2.2	75-100	1.9
4	falling	yes	4.8	50-75	3.0
5	wildlife	yes	130.2	0-25	16.3
6	yarding	yes	63.0	50-75	39.4
7	yarding/old road Xing	yes	75.2	0-25	9.4
8	falling/yarding	yes	55.4	75-100	48.5
9	falling/yarding	no	14.6	50-75	9.1
10	yarding	no	6.2	25-50	2.3
11	yarding	yes	22.0	0-25	2.8
12	falling/yarding	yes	7.5	50-75	4.7
13	falling	yes	13.5	75-100	11.8
14	yarding	yes	56.0	50-75	35.0
15	in-stream deposit	n/a	(surface area: 3.1 m^2)	n/a	n/a
16	falling/yarding	yes	15.6	75-100	13.7
17	in-stream deposit	n/a	(surface area: 1.1 m^2)	n/a	n/a
18	yarding	yes	3.9	75-100	3.4
	TOTALS	12 delivered	479.3		202.5

Total Area of Ground Surveyed = 0.2 hectares

Total Length of Stream Bank Surveyed = 159 meters

Disturbed Soil per Hectare = 2396.5 m^2/ha.

Area Exposed Soil per Hectare = 1012.5 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 189.9 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 949.5 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 173.6 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 868.0 m^2/ha**

* The features that delivered to water but were not directly attributable to current harvest practices, as wildlife activity, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	7	93.5	90.0	47.4
falling	3	16.7	16.7	8.9
falling/yarding	4	76.0	66.9	35.2
wildlife	1	16.3	16.3	8.5

NARRATIVE:

The SR-02NB survey includes portions of the SR-02 survey area that drain to the un-buffered type 4 tributary upstream of where it enters the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvest using cable yarding systems in the vicinity of a type 4 water without stream buffers. Cable yarding within and across the un-buffered type 4 stream resulted in several erosion features that delivered substantial amounts of sediment to the stream. Yarding and tree falling activities disturbed both upper and lower stream banks on both sides of the stream as well as the streambed. A puncheon culvert from an old road crossing was disturbed by yarding (feature 7), releasing sediment from the old road fill that had been revegetated prior to the harvest. The upper stream banks on one side of the stream were also disturbed by elk trails.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sears Cr.	Survey Date	7/11/95
Site Id #	W-01	Survey Id #	SR-02NB
Water Type	4	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
2	yarding	no longer eroding - revegetated			
3	falling	no longer eroding - revegetated			
4	falling	no	2.2	25-50	0.8
5	wildlife	yes	13.0	0-25	1.6
6	yarding	yes	63.0	0-25	7.9
7	yarding/old road Xing	yes	66.5	25-50	24.9
8	falling/yarding	yes	55.4	25-50	20.8
9	falling/yarding	no	5.5	25-50	2.1
10	yarding	no	2.6	50-75	1.6
11	yarding	yes	22.0	0-25	2.8
12	falling/yarding	yes	7.5	50-75	4.7
13	falling	yes	13.5	75-100	11.8
14	yarding	yes	56.0	50-75	35.0
15	in-stream deposit	n/a	(surface area: 3.1m^2)	n/a	n/a
16	falling/yarding	yes	15.6	25-50	5.9
17	in-stream deposit	n/a	(surface area: 1.1m^2)	n/a	n/a
18	yarding	yes	3.9	75-100	3.4
	TOTALS	7 delivered	326.7		

Total Area of Ground Surveyed = 0.2 hectares

Total Length of Stream Bank Surveyed = 159 meters

Disturbed Soil per Hectare = 1633.5 m^2/ha.

Area Exposed Soil per Hectare = 616.5 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 103.4 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 517.0 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 101.8 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 509.0 m^2/ha**

* The features that delivered to water but were not directly attributable to current harvest practices, as wildlife activity, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	6	75.6	63.3	61.2
falling	2	12.6	11.8	11.4
falling/yarding	4	33.5	26.7	25.8
wildlife	1	1.6	1.6	1.6

NARRATIVE:

The SR-02NB survey includes portions of the SR-02 survey area that drain to the un-buffered type 4 tributary upstream of where it enters the Sears Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this survey were clearcut harvest using cable yarding systems in the vicinity of a type 4 water without stream buffers. Six of the 11 harvest-attributable erosion features found to deliver sediment to the stream in the 1994 survey, conducted 6 months following harvest, were continuing to deliver in the 1995 survey (17 months following harvest). However, the extent of exposed soils associated with harvest erosion features that delivered sediment to the stream was reduced to 59% of that measured in 1994, due to natural revegetation that occurred between the two surveys. Chronic sediment delivery was caused by erosion associated with cable yarding and tree falling activities within and across the un-buffered type 4 stream, including disturbance of upper and lower stream banks from harvest activities within the steep inner gorge. All of the erosion features that delivered were located within 10 meters of the stream. Two notable in-stream sediment deposits (features 15 and 17) had covered the streambed with a layer of fine sediment averaging 35 to 43 cm deep. Discontinuous sediment deposition was observed to the confluence with Sears Creek.

BMP EFFECTIVENESS RATING:

Cable Yarding without Stream Buffers: NOT EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Sears Creek

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut harvest with cable-yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	35	4/20/93	52	4/20/93
Post-Treatment Survey #1:	55	7/6/94	59	7/6/94
Change from Pre-Treatment Score:	+20		+7	
Net Change (Control-Treatment):	+13			
Post-Treatment Survey #2:				
Change from Pre-Treatment Score:				
Net Change (Control-Treatment):				

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
There was an increase in both control and treatment scores, but the treatment increased by a greater amount, hence there are no apparent effects of the harvest practices on the Type 3 stream. The RMZ was no entry in the area of the study reach, and this was effective. The increase in score is substantial, and it may reflect the different times of year and streamflow regimes when the observations were made. Score increases are primarily due to decreases in bank erosion, fresh sediment deposits, and fines in pools. The seasonal effect may be reflected in the degree of bank vegetation present in early spring versus early summer, as well as more fines moving through the reach in spring. This is a low gradient reach that does have the potential to accumulate fine sediment, especially in pools. The banks are highly erodible, and appear to be disturbed by elk fairly frequently. The effects of logging the original forest are also apparent, and it appears that both control and treatment reaches were formerly used as yarding corridors.

In-Stream Photo-Point Survey Comparison Summary

Site: Sears Creek Survey Dates: 4/29/93 & 7/6/94

Study Reach Descriptions: Both reaches were on Sears Creek, with the control reach located upstream of the harvest unit.

Indicators of in-channel changes		Control PS-02 Yes	Control PS-02 No	Treatment PS-01 Yes	Treatment PS-01 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?			X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?			X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?			X		X
4. Is there evidence of increased deposition or storage of fine or coarse sediment?			X		X
5. Are there changes in woody debris? (indicate numbers of windthrown trees documented over the survey period)	Increase in large WD?		X		X
	Increase in small WD?		X	X	
	Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?			X		X

Summary:

Very little change was apparent in either study reach over the monitoring period. There were no new windthrown trees down across the stream in either reach. The dense stream bank vegetation and lower stream flows in the 1994 surveys made comparisons difficult, but enough specific features were identifiable to substantiate the conclusion of little change in stream channel features and no in-stream effects from harvest practices.

BMP Effectiveness Rating: Effective

Sears Creek - Channel Substrate Transects Survey Results

Treatment Reach: Type 3 Stream with RMZ

Survey Date					Survey Date				
4/19/93					10/5/94				
Survey ID	Transect No.	Ave. % Fines	Dominant PS	Subdominant PS	Survey ID	Transect No.	Ave. % Fines	Dominant PS	Subdominant PS
SU-01	1	37	gravel	fines	SU-01	1	56	fines	gravel
	2	28	gravel	fines		2	83	fines	none
	3	16	gravel	fines		3	76	fines	gravel
	4	69	fines	gravel		4	60	fines	gravel
	5	61	fines	gravel		5	58.0	fines	gravel
	6	68	fines	gravel		6	34	gravel	fines
	7	38	gravel	fines		7	65	fines	none
	8	48	gravel	fines		8	50	gravel	fines
	9	50	gravel	fines		9	53	fines	gravel
	10	70	fines	gravel		10	70	fines	gravel

Reach Average Percent Fines:	48.5		Reach Average Percent Fines:	60.5

Pebble Count Summary:

	Size Class	No. of Particles	% of Total		Size Class	No. of Particles	% of Total
sand & smaller	<2mm	41	41	sand & smaller	<2mm	32	32
fine gravel	2-6mm	14	14	fine gravel	2-6mm	33	33
gravel	6-64mm	45	45	gravel	6-64mm	35	35

These survey results reflect an increase in the reach average percent fines over the monitoring period in the treatment reach. Likewise, the pebble count data indicates a reduction in the proportion of gravel in non-pool depositional zones of the reach (e.g., riffles and bars). The control reach was less dominated by fines than the treatment reach, both pre and post treatment, although there was small increase in fines in the control reach. While the results indicate a greater extent of streambed fining in the treatment reach relative to the control, this change may be within the range of year to year and/or seasonal variability (i.e., spring versus fall sampling). Because of this unknown, and because sampling was not conducted at the same time of year pre and post treatment, the results are inconclusive as to a forest practice effect, even though sediment sources were identified in the harvest unit, upstream of the treatment reach (re: sediment routing survey findings of sediment delivery via un-buffered type 4 stream). Analysis of stream channel maps made during the surveys indicates there were no significant movements of sediment storage elements (LWD) within either reach. The treatment reach has more woody debris than the control, indicating a higher potential to store sediment.

BMP Effectiveness Rating: INDETERMINATE

Control Reach: Type 3 Stream, upstream of treatment reach on same stream.

Survey Date					Survey Date				
4/19/93					10/5/94				
Survey ID	Transect No.	Ave. % Fines	Dominant PS	Subdominant PS	Survey ID	Transect No.	Ave. % Fines	Dominant PS	Subdominant PS
SU-02	1	43	gravel	fines	SU-02	1	9	gravel	fines
	2	39	gravel	fines		2	14	gravel	fines
	3	31	gravel	fines		3	41	gravel	fines
	4	6	gravel	fines		4	43	gravel	fines
	5	18	gravel	fines		5	23.0	gravel	fines
	6	9	gravel	fines		6	44	gravel	fines
	7	40	gravel	fines		7	55	fines	gravel
	8	24	gravel	fines		8	40	gravel	fines
	9	33	gravel	fines		9	16	gravel	fines
	10	32	gravel	fines		10	30	fines	gravel
Reach Average Percent Fines:		27.5			Reach Average Percent Fines:		31.5		

Pebble Count Summary:

	Size Class	No. of Particles	% of Total		Size Class	No. of Particles	% of Total
sand & smaller	<2mm	33	32	sand & smaller	<2mm	18	18
fine gravel	2-6mm	5	5	fine gravel	2-6mm	22	22
gravel	6-64mm	64	63	gravel	6-64mm	60	60

These survey results reflect a slight increase in the reach average percent fines over the monitoring period, but less than the increase observed in the treatment reach. Gravels were the dominant substrate size class in the control reach both pre and post treatment, whereas fines were dominant in the treatment reach in the post-treatment survey, and co-dominant (fines and gravels being about equally represented) in the pre-treatment survey.

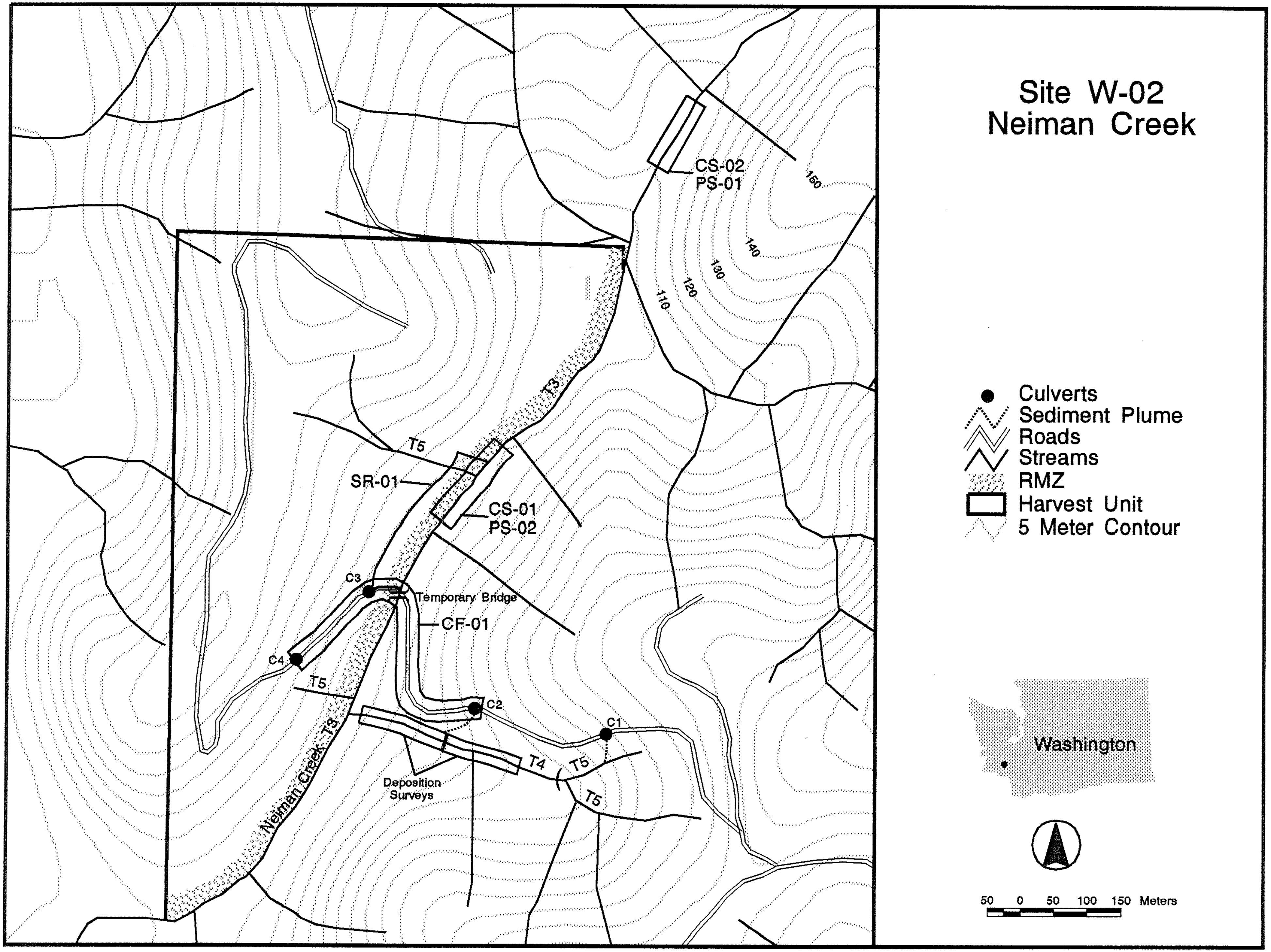
Site W-02 : Neiman Creek

The Neiman Creek site includes 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 classified as Melbourne loam, 15-30% slope phase. The disturbed slope stability for this soil type is unstable, with a moderate hazard rating for cutbank/fill/sidecast road construction, and a medium hazard rating for erosion potential. The harvest BMP slope hazard category is low, with stream valley side slopes under 20%. The road construction BMP slope hazard category is moderate, with hillslope gradients along the road segment evaluated ranging from 7-42%.

Neiman Creek is a 1st order tributary to the South Fork Chehalis River that flows along the eastern boundary of the harvest unit. Neiman Creek is depicted as a Type 4 on the DNR Water Type map and the approved FPA, but was treated with a RMZ during the logging of the site. It meets the physical criteria for a Type 3 water, and salmonids were observed during stream surveys. A zero order Type 5 tributary to Neiman Creek is located within the portion of the harvest unit evaluated. The tributary was not buffered 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 wetland along its floodplain. Channel morphology is classified as pool-riffle, with a wide-alluviated valley form. The treatment reach on Neiman Creek has an average active channel width of 5 meters and an average channel gradient of 1%. In the area of new road construction on the east side of Neiman Creek, there is a tributary to Neiman Creek that runs parallel to the newly constructed road. This stream is mapped as a Type 4, but appears to meet the criteria for a Type 3 for much of its length.

Forest practices conducted at this site include a 32 hectare clearcut harvest 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 meter temporary bridge was installed over Neiman Creek. A RMZ, with ground-based harvesting adjacent to it, was established along the west bank of Neiman Creek. RMZ width averaged 28 meters in the survey area along Neiman Creek. The harvest in the portion of the unit evaluated was completed in February 1994. Road construction was completed in the fall of 1993. The temporary bridge was removed in the fall of 1994.

The BMPs evaluated at this study site include the RMZ with adjacent ground-based harvesting, ground-based harvesting in the vicinity of the Type 5 stream without stream buffers, and new road construction practices, including water crossings (temporary bridge), road design (relief culverts), and road construction techniques (cut and fill slopes). Two study reaches were established along Neiman Creek, including a treatment reach along the RMZ above the temporary bridge and a control reach upstream of the harvest unit boundary. Channel condition and photo point surveys were conducted on both study reaches in February 1994 and May 1995. Sediment routing surveys evaluating harvest in the vicinity of the lower section of the un-buffered Type 5 stream and a portion of the RMZ were conducted in August 1994 and July 1995. Surveys conducted to evaluate road construction practices included culvert condition surveys in April 1994 and June 1995 and cutbank/fillslope surveys in April 1994 and May 1995. The cutbank/fillslope surveys evaluated the road segment draining to the temporary bridge crossing as well as effectiveness of BMPs employed at the crossing. Sediment deposition surveys were conducted in June 1995 in conjunction with the culvert condition survey to evaluate hillslope erosion and sediment storage and in-stream deposition of sediment discharged via relief culverts.


Site W-02
Neiman Creek
Culverts
Sediment Plume
Roads
Streams
RMZ
Harvest Unit
5 Meter Contour
Washington
50 0 50 100 150 Meters
CS-02
PS-01
150
140
130
120
110
T3
T5
SR-01
CS-01
PS-02
C3
Temporary Bridge
CF-01
C4
C2
C1
T4
Deposition Surveys
Neiman Creek T3

Harvest BMP Effectiveness Summary

Study Site:	W-02: Neiman Creek - Clearcut harvest with RMZ, and harvest without stream buffers						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding
		WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing						
	SR-01BU	Effective					
	SR-01NB			Effective			
Case Narrative:	The RMZ was effective at preventing direct sediment delivery to Neiman Creek and the adjacent wetlands on its floodplain. The RMZ was not entered by harvesting or yarding equipment in the vicinity of the survey area. Sediment delivery to the un-buffered Type 5 stream, from skid trail yarding features adjacent to and crossing the stream, was documented during the first year following harvest, but delivery from these features was not chronic. There was a substantial degree of natural revegetation of harvest erosion features between the first and second year surveys.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition						
	CS-01/CS-02	Effective					
	Photo Point						
	PS-02/PS-01	Effective					
Case Narrative:	No in-stream effects of the timber harvest were observed in the Type 3 stream buffered by the RMZ. No new windthrown trees were observed in the RMZ study reach over the monitoring period. In addition to the Type 3 study reach, the photo-point survey also covered the mouth of the unbuffered Type 5 tributary. Siltation of the streambed was observed, attributable to short-term sediment delivery from yarding features within the clearcut.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE		EFFECTIVE			

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Neiman Creek	Survey Date	8/10/94
Site Id #	W-02	Survey Id #	SR-01BU
Water Type	3, 5	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
5	windthrow	no	3.4	75-100	3.0
6	skid trail	no	40.8	75-100	35.7
7	skid trail	no	62.9	0-25	7.9
8	skid trail	no	433.3	50-75	270.8
9	skid trail	no	1124.8	50-75	703.0
	TOTALS	0 delivered	1665.2		1020.4

Total Area of Ground Surveyed = 0.9 hectares

Total Length of Stream Bank Surveyed = 170 meters

Disturbed Soil per Hectare = 1850.2 m^2/ha

Area Exposed Soil per Hectare = 1133.8 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	4	1017.4	0.0	n/a
windthrow	1	3.0	0.0	n/a

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Neiman Creek, which was buffered by a RMZ, and the lowermost segment of the type 5 tributary where it flows through the Neiman Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this sediment routing survey were clearcut harvesting using ground-based equipment on one side of a type 3 stream that was buffered with a RMZ. The RMZ, which averaged 28 meters in width and was not entered by equipment in the vicinity of the survey area, was effective at preventing sediment delivery directly to Neiman Creek despite extensive areas of disturbed and exposed soils immediately adjacent to and upslope of the buffer.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Neiman Creek	Survey Date	7/19/95
Site Id #	W-02	Survey Id #	SR-01BU
Water Type	3, 5	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
5	windthrow	no	3.4	50-75	2.1
6	skid trail	no	42.0	0-25	5.3
7	skid trail	no longer eroding - revegetated			
8	skid trail	no	433.3	25-50	162.5
9	skid trail	no	1124.8	0-25	140.6
	TOTALS	0 delivered	1603.5		310.5

Total Area of Ground Surveyed = 0.9 hectares

Total Length of Stream Bank Surveyed = 170 meters

Disturbed Soil per Hectare = 1781.7 m^2/ha

Area Exposed Soil per Hectare = 345.0 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	3	308.4	0.0	n/a
windthrow	1	2.1	0.0	n/a

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Neiman Creek, which was buffered by a RMZ, and the lowermost segment of the type 5 tributary where it flows through the Neiman Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated with this sediment routing survey were clearcut harvesting using ground-based equipment on one side of a type 3 stream that was buffered with a RMZ. The RMZ, which averaged 28 meters in width and was not entered by equipment in the vicinity of the survey area, continued to be effective at preventing direct sediment delivery to Neiman Creek from harvest site erosion. The extent of exposed soils in harvest areas adjacent to and upslope of the buffer went from about 11% of the survey area in 1994 (6 months following harvest) to about 4% of the survey area in 1995 (17 months following harvest) due to vigorous natural revegetation. As had been observed at other clearcut sites west of the Cascades, thistle (*Cirsium sp.*) and tansy wort (*Senecio jacobaea*) were the most common plants to colonize the site.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Neiman Creek	Survey Date	8/10/94
Site Id #	W-02	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	yes	472.5	25-50	177.2
2	skid trail	yes	230.0	50-75	143.8
3	skid trail	no	532.4	0-25	66.6
4	skid trail	no	93.1	25-50	34.9
	TOTALS	2 delivered	1328.0		422.5

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 44 meters

Disturbed Soil per Hectare = 3320.0 m^2/ha

Area Exposed Soil per Hectare = 1056.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 321.0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 802.5 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 321.0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 802.5 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	4	422.5	321.0	100

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the un-buffered type 5 tributary upstream of where it enters the Neiman Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated at Neiman Creek with this sediment routing survey were clearcut harvesting using ground-based equipment in the vicinity of a type 5 stream without stream buffers. The two skid trail features associated with sediment delivery were located within 10 meters of and roughly parallel to the unbuffered type 5 stream. (Note: although designated as skid trails, these erosion features also included disturbance by adjacent tree falling and yarding to the trails.) In two places the skid trails crossed the stream. Sediment deposition in the lower part of the type 5, where it entered the RMZ, was documented in the photo point survey conducted along Neiman Creek.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Neiman Creek	Survey Date	87/19/95
Site Id #	W-02	Survey Id #	SR-01NB
Water Type	5	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	472.5	0-25	59.1
2	skid trail	no	166.5	0-25	20.8
3	skid trail	no	532.4	0-25	66.6
4	skid trail	no	93.1	0-25	11.6
	TOTALS	0 delivered	1264.5		158.1

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 44 meters

Disturbed Soil per Hectare = 3161.3 m^2/ha

Area Exposed Soil per Hectare = 395.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	4	158.1	0.0	n/a

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the un-buffered type 5 tributary upstream of where it enters the Neiman Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated at Neiman Creek with this sediment routing survey were clearcut harvesting using ground-based equipment in the vicinity of a type 5 stream without stream buffers. The two skid trail features that had been observed to deliver sediment to the unbuffered type 5 stream in the 1994 survey (features 1 and 2) were heavily revegetated in 1995, as were the other erosion features in the survey area. (Note: although designated as skid trails, these erosion features also included disturbance by adjacent tree falling and yarding to the trails.) Feature 2 no longer had exposed soils within 10 meters of the stream. In the two places where the skid trails crossed the stream, there was no evidence of continued sediment routing to the stream from these erosion features, although fresh in-stream sediment deposits were observed both upstream and downstream of the crossing area. Apparently, the source of this sediment is hillslope erosion in the upper part of the drainage area, or channel erosion in the deeply incised segment of the stream upstream of the survey area. Within the SR-01NB survey area, the type 5 channel was not well-defined and surface flow was discontinuous. Sediment deposition in the lower part of the type 5, where it entered the RMZ and merged with the Neiman Creek floodplain, was documented in the photo point survey conducted along Neiman Creek. Because sediment delivery within the survey area was not chronic, the BMP rating is effective.

BMP EFFECTIVENESS RATING:

Ground-Based Yarding without Stream Buffers: EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Neiman Creek W-02

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Preliminary Surveys*:	45	2/2/94	37	2/2/94
Post-Treatment Survey #1:	46	5/31/95	38	5/31/95
Change from Pre-Treatment Score:	+1		+1	
Net Change (Control-Treatment):	0			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
Both control and treatment reaches are heavily influenced by beaver activity, and are characterized by a series of impounded or slow-moving pools punctuated by short glides or riffles. Substrates in these low-gradient reaches are either fine sediment or woody organic detritus. Streamside wetlands have developed on the floodplain, especially along the treatment reach. The Riparian Management Zone averages 28 meters in width and extends from the edge of the non-forested wetland to the harvest unit which is only on the right side of the stream. The channel condition surveys did not detect any impacts of the harvest practices on the Type 3 stream buffered by the RMZ, but siltation was observed at the mouth of a Type 5 tributary where it entered the floodplain wetland.

(* Note: Timing of the initial surveys was concurrent with the harvest activities. It was noted at the time of these surveys that no immediate impacts from logging were apparent in the treatment reach.)

Road BMP Effectiveness Summary

Study Site:	W-02: Neiman Creek - New Road Construction				
		BMP Effectiveness Ratings			
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings WAC 222-24-040	Relief WAC 222-24-025	Cutslopes WAC 222-24-030	Fillslopes
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition: CC-01		Not Effective		
	Cutbank/Fillslope: CF-01	Effective		Not Effective	Effective
Case Narrative:	Three of the four relief culverts evaluated delivered sediment to streams, including Neiman Creek (Type 3) and its Type 4 and 5 tributaries, with channelized and overland flow sediment transport distances below these three culverts ranging from 15-85 meters. At a fourth relief culvert, the downslope sediment transport distance was 120 meters and came within 15 meters of Neiman Creek, but no delivery was documented by the 1995 survey (about 20 months following road construction). BMPs employed for the temporary bridge crossing of Neiman Creek were effective; exposed soils at the bridge location had completely re-vegetated by the 1995 survey. Chronic erosion of cutslopes with sediment delivery to Neiman Creek and its tributaries was documented. Highly erodible soils at this road construction site were still over 75% exposed on most cutslope sections by the 1995 surveys, in spite of attempts to stabilize exposed soils by grass seeding (without mulching). Hay bales placed in ditches were overwhelmed by the amount of sediment and ditch flow and were not effective at preventing delivery to Neiman Creek. Ditch diversion into a sediment trap on one side of the road reduced delivery somewhat in the second year. Material eroded from fillslopes delivered to Neiman Creek during the first year, but delivery from fillslopes was not chronic.				
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Deposition Surveys		Not Effective		
Case Narrative:	In-stream effects of sediment delivery via relief drainage were evaluated by direct measurement of in-stream sediment deposition in a tributary to Neiman Creek (mapped as a Type 4, but appears to meet criteria for Type 3 for much of its length). A total of 121 m^3 of freshly deposited sediment, eroded from two road drainage segments (522 m of road), was delivered by two relief culverts. This deposition covered the streambed and portions of the floodplain with a layer of sediment ranging from 3-42 cm thick, and averaging 11 cm thick. The deposition was continuous from the confluence with Neiman Creek to a point 240 meters upstream.				
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE	NOT EFFECTIVE	NOT EFFECTIVE	EFFECTIVE

Neiman Creek Culvert Condition Survey Results

Site: W-02: Neiman Creek
Culvert Condition Survey: CC-01
Survey Dates: 4/94 & 6/95
Date of Construction: 10/93

Site BMP Effectiveness Rating:

Stream X-ing: n/a
Relief: Not Effective

Culvert # and Type	Point of Observation	Extent of Erosion Year 1994	1995	Culvert Spacing (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-1, Relief	Inflow	Severe	Severe	269m	Constant	Y			No
	Outflow	Severe	Moderate	(269m)	Decrease	Y	Yes, 24m down slope	Yes, Type 5	
C-2, Relief	Inflow	Severe	Severe	253m	Constant	Y			No
	Outflow	Severe	Severe	(253m)	Constant	Y	Yes, 85m down slope	Yes, Type-4	
C-3, Relief	Inflow	Severe	Severe	43m	Constant	Y			No
	Outflow	Moderate	Slight	(157m)	Decrease	Y	Yes, 15m down slope	Yes, Type 3	
C-4, Relief	Inflow	Moderate	Severe	157m	Increase	Y			Yes
	Outflow	Moderate	Severe	(220m)	Increase	Y	Yes, 120m down slope	No	

Comments/ Notes Summary:

The culvert condition survey at this site only evaluated the four relief culverts along the road segment draining to Neiman Creek; the temporary bridge crossing of Neiman Creek was evaluated as part of the Cutbank/Fillslope Survey of the road segment. The average spacing between relief culverts was 226 meters (with 275 m between C2 and Neiman Creek and 43 m between C3 and Neiman Creek), and the average road gradient was 8 %. In-stream sedimentation from eroded road material delivered via relief drainage at this site was perhaps the most extensive case of such effects observed over the course of the study. The road constructed at the Neiman Creek site had a well compacted travel surface covered by a layer of crushed-rock at least 15 cm. thick. However, erosion of cutslopes and ditches constructed in the highly erodible soils was severe. Culvert fill armoring was rated as poor at all the inflows and outflows for both 1994 and 1995. At the time of the 1994 survey, severe erosion was observed on the cutslopes and ditches. Channel development and overland sediment transport was observed downslope of the outflow at all four culverts in 1994, with sediment delivery to surface waters occurring at three of the four. Sediment transport downslope of culverts 1 and 2 was exceptional in that the sediment was transported via both overland flow and channelized flow across the floor of the second -growth forest. Relief drainage from culvert 2 traveled 85 meters downslope before delivering sediment to a type 4 tributary to Neiman Creek. In-stream deposition surveys measured 89 cubic meters of unambiguous sediment deposition in the type 4 stream below the delivery point of the discharge from C2, continuing for a distance of 135 meters to the confluence of Neiman Creek. The fine sediment deposition formed a continuous layer up to 44 cm thick (ave. depth of deposition was 12 cm.), covering the active stream channel and portions of the floodplain. Hillslope storage of eroded material was dominant the first year following road construction, but by 1995, channelization of the hillslope produced erosion that was equivalent to the volume stored on the hillslope. Upstream of the delivery point of drainage from C2, another 32 cubic meters of continuous in-stream sediment deposition that was attributable to discharges from culvert 1 to a tributary of the same stream, was measured over a stream distance of 105 meters (ave. depth 10 cm). Erosion from the cutslope and ditch was severe enough to plug the inflow of culvert 3 in 1994 and the inflow of culvert 1 in 1995. Plugging of the inflow of culvert 1 undoubtedly contributed to the severe ditch erosion down-gradient of the relief inflow, and increased the magnitude of sediment delivery from culvert 2. Slash berms left along the base of the fillslopes during road construction were ineffective at preventing channel initiation and sediment transport/delivery. In 1995, a channel that developed below the outflow of culvert 4 extended 120 meters downslope across the clearcut, but stopped in an equipment rut 15 meters short of the ordinary high water mark of Neiman Creek. There is the potential for delivery if channelization continues. As noted in the Cutbank/Fillslope Survey, dry grass seeding was ineffective, and other soil stabilization BMPs such as hydromulching were not employed to stabilize soils exposed by road construction at this site. Water bars were constructed across the road tread but they were not connected with or diverting flows from the ditch.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Neiman Creek
Survey Id #'s	CF-01
Survey Dates	4/14/94 & 5/31/95
Water Type	3
Road Construction Date:	10/93
Length of Road Draining to Stream	497 meters

Range Road Gradient	6-13 %
Average Road Gradient	9.2 %
Range Hillslope Gradient	7-42 %
Average Hillslope Gradient	23.6 %
Range Cutslope Gradient	28-60 deg.
Average Cutslope Gradient	44.0 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	67		80	
% Observations w/med. slope height	33		20	
% Observations w/high slope height	0		0	
	1994	1995	1994	1995
% Observations w/0-25% exposed soils	0	0	5	0
% Observations w/26-50 % exposed soils	0	0	5	5
% Observations w/51-75 % exposed soils	16	21	25	75
% Observations w/76-100 % exposed soils	84	79	65	20
% Observations w/Evidence of Erosion	100	100	100	100
Evidence of Erosion w/delivery to surface water	yes	yes	yes	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	yes	yes

BMP Effectiveness Ratings: **Not Effective** **Effective**

Temporary Bridge Crossing of Neiman Creek: Effective

COMMENTS:

The forest practices evaluated with this survey were cut and fill slope construction practices and a stream crossing of a type 3 water with a temporary bridge. The road construction was completed in the fall of 1993. The temporary bridge was removed between the 1994 and 1995 surveys. Substantial soil erosion of the cutslopes and ditches was observed in both the 1994 and 1995 surveys. Types of erosion observed included sheetwash erosion, slumping, and gullying on both cut and fill slopes, and gully erosion in ditches. During the 1994 survey it was noted that the hay bales placed in ditches and below fillslope erosion sites were being overwhelmed by the amount of sediment and flowing water, and were not effective at preventing sediment delivery to Neiman Creek. Unambiguous deposits of road sediment were observed in Neiman Creek in the vicinity of ditch outflows. Sediment was delivered to Neiman creek via direct entry ditch-lines in both years, although the amount of sediment delivered between the 1994 and 1995 surveys was reduced following the construction of sediment traps, the re-routing of ditch flow into sediment t raps, and grass seeding and natural revegetation of some exposed areas. In 1994, there was evidence of delivery of material eroded from fillslopes to Neiman Creek, but there was not evidence of continuing direct delivery from fillslopes at the time of the 1995 survey. While ditch diversion into a sediment trap prevented a portion of cutslope and ditch erosion from continuing to deliver to Neiman Creek, substantially reducing the magnitude of sediment delivery in the second year of road life, continued delivery from exposed cutslopes and ditches down-gradient of the sediment trap and on the other side of Neiman Creek was evident in the 1995 survey. Hay bales were only partially effective at trapping sediment at the ditch outflow. As indicated from the above information on the percent of exposed soil in both survey years, revegetation of the cutslopes was very slow. The evaluation of practices employed at the temporary bridge installation, included within the surveyed segment, found that exposed slopes at the crossing site were completely re-vegetated by the time of the 1995 survey, with no evidence of chronic sediment delivery, therefore the temporary crossing BMPs are rated effective.

Site W-03: Train Whistle

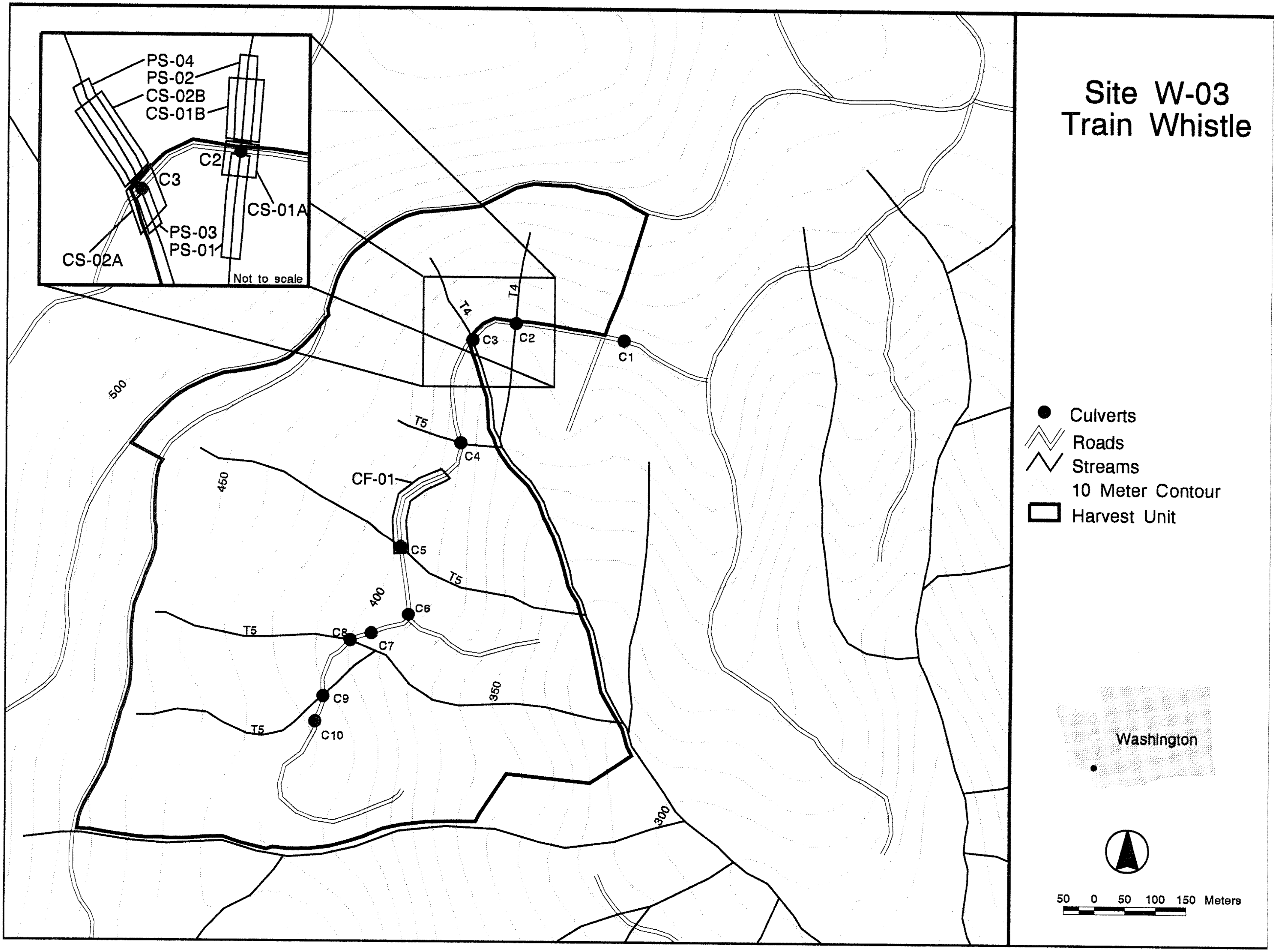
Train Whistle is a road construction and harvest site located in north-central Cowlitz County in the Willapa Hills physiographic region. Underlying geology consists of upper Eocene volcaniclastic sedimentary and volcanic rock members of the Goble volcanics. Soils are classified as Olympic gravelly silt loam with two slope phases, 30-65% slopes along stream valleys and 0-30% slopes in other areas of road construction. Both soil phases have a disturbed soil slope stability rating of stable, with soil hazard ratings of moderate and medium, respectively, for cutbank/fill/sidecast road construction and erosion potential. The road construction BMP slope hazard category for the site is high, with hillslope gradients ranging from 11-68%. The harvest BMP slope hazard category is high, with stream valley slopes in the survey areas ranging from 45-82%.

In-stream surveys were conducted on one zero order and one 1st order stream, which are tributaries to Mulholland Creek in the Coweeman River basin. These streams are depicted as Type 5s on the DNR Water Type map and on the FPA, however, they meet the physical criteria for Type 4 Waters. The study streams have step-pool and cascade channel morphologies in V-shaped valleys. Channel gradients are 26-31% and active channel widths are about 2 meters. In addition to these Type 4 streams, the section of new road construction evaluated crosses four Type 5 streams in the same watershed.

Forest practices conducted at this site include a clearcut harvest using both ground-based (shovels) and cable yarding methods, and approximately 6 km of road construction. 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, cleaning of draws and streambeds upstream of culvert inlets, and grass seeding of road cuts and fills. The road construction was completed by August 1993. Timber harvest was completed in February 1994.

BMPs evaluated at this site are the new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes), and ground-based harvesting in the vicinity of Type 4 streams without stream buffers. Preliminary channel condition surveys on two Type 4 streams were conducted in May 1993, prior to the road being built, with survey reaches located in reference to the flagged P-line for the new road construction. It was intended that the reaches upstream of the road would serve as controls for the downstream reaches evaluating the effects of the road crossings. However, prior to the follow-up surveys, the area upstream of the road was harvested. Therefore, follow-up surveys conducted in July 1994 were used to make before-after comparisons of in-stream conditions. The channel condition surveys were split into two reaches each, with one reach located upstream of the road for evaluation of harvest practices, and one reach representing the immediate area of road fill and culvert placement and the stream segment below the crossing. Photo point surveys were conducted on the Type 4 treatment reaches above and below the two road crossings in September 1993 (immediately following the completion of road construction), with follow-up surveys in July 1994. Cutbank/fillslope surveys were conducted on a segment of the new road construction in September 1993 and July 1994. Culvert condition surveys covering over 1100 meters of newly constructed road were conducted in September 1993 and May 1995.

Site W-03
Train Whistle



Harvest BMP Effectiveness Summary

Study Site: W-03: Train Whistle - Clearcut harvest without stream buffers

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050) — Ground-based Yarding WAC 222-30-070	Harvest w/ RMZ & Streambank Integrity BMPs — Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters) — Ground-based Yarding WAC 222-30-070	Harvest with no buffers (Type 4 and/or 5 Waters) — Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) — Ground-based Yarding WAC 222-30-070	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) — Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted to evaluate harvest practices.						
Case Narrative:	While no sediment routing or other erosion/delivery surveys were conducted to evaluate this harvest practice, it was noted during in-stream surveys that stream valley hillslopes were eroding due to disturbance by shovel logging activities.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01B			Not Effective			
	CS-02B			Not Effective			
	Photo Point:						
	PS-02			Not Effective			
	PS-04			Indeterminate			
Case Narrative:	Channel condition and photo point surveys conducted on two Type 4 reaches upstream of the new road construction at this unit were originally intended to serve as controls for the downstream reaches affected by road crossings. However, the area upstream of the road was harvested between the 1993 and 1994 surveys, and the surveys were used to make before/after comparisons of in-stream conditions affected by timber harvest. Channel condition and photo-point surveys reflected disturbance of streambed sediment storage elements (both large and small woody debris), including large, old cull logs moved out of the channel during timber yarding, physical disturbance of upper and lower stream banks, increased streambed mobility, numerous fresh sediment deposits and surface fines, and extensive slash covering much of the substrate. One of the photo point surveys was rated "Indeterminate" due to poor photo quality in the follow-up survey and an inability to make adequate year-to-year comparisons because the stream channel was obscured by slash at many photo points.						
	OVERALL SITE BMP EFFECTIVENESS RATING:			NOT EFFECTIVE			

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Train Whistle W-03

Treatment Survey ID#: CS-01B & CS-02B   Water Type: 4
Control Survey ID#: n/a   Water Type: n/a

BMP(s) Evaluated: Ground-based Yarding (clearcut harvest) without stream buffers

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-01B	CS-02B		There were no control reaches for this evaluation.	
Pre-Treatment Surveys:	45	43	5/13/93		
Post-Treatment Survey #1:	17	16	7/27-28/94		
Change from Pre-Treatment Score:	-28	-27			
Net Change (Control-Treatment):	n/a	n/a			

BMP EFFECTIVENESS RATING: NOT EFFECTIVE

Case Narrative:

These surveys were conducted upstream of the new road construction evaluated with the CS-01A and CS-02A survey reaches. The decrease in channel condition scores in this before-after comparison reflect the effects of clearcut harvesting using shovels, without stream buffers. Both study reaches had steep step-pool morphology with average channel gradients of 31% and 26%. Steps were formed by both natural LWD and large cull logs from the logging of the original forest. It was noted that some cull logs were moved out of the channel during logging operations. Other channel changes include disturbance of upper and lower stream banks, flow deflection onto banks by logging slash in the channel, increases in the extent of fresh sediment deposits and surface fines, increased streambed mobility, destabilization of sediment storage elements formed by LWD, and extensive slash covering the streambed. A larval Pacific Giant Salamander was observed in the CS-01B reach during the follow-up survey.

In-Stream Photo Point Survey Summary

Site: Train Whistle Survey dates: 9/9/93 & 7/27/94
Survey Id: PS-02 Treatment Reach (no Control comparison)
Water Type: 4 Reach Length: 57.4 m.

Indicators of in-channel changes	Yes	No	Photo/Field Note References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?	X			20 vs.	13	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?	X			18 vs.	11	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X			19,21,22	14,15	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X			19,21,22	14,15	
5. Are there changes in woody debris?						
Increase in large WD?	X			20 vs.	13	
Increase in small WD	X			22 vs.	17	
Decrease in WD?	X			18 vs.	11	
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?	X			17 vs.	9	

BMP Effectiveness Rating: Not Effective

Summary:

Photo survey PS-02 is located upstream of the road crossing, on the same type 4 stream on which PS-01 is located. PS-02 was initially intended to serve as a control reach for the area below the road crossing, but the area was harvested between the 1993 and 1994 surveys. Therefore, the PS-02 surveys are used for a before/after evaluation of the impacts of clearcut harvesting on an unbuffered type 4 stream. Substantial changes noted between the 1993 and 1994 surveys include removal of large and small woody debris within the channel that had been serving as sediment storage structures, and an increase in bank erosion through physical disturbance. Large amounts of logging slash placed in the channel obscured some of the features in the 1994 survey that were visible in 1993. In areas where the channel substrate was visible, the substrate shows increases in bright, fresh sediment deposition.

In-Stream Photo Point Survey Summary

Site: Train Whistle Survey dates: 9/8/93 & 7/27/94
Survey Id: PS-04 Treatment Reach (no Control comparison)
Water Type: 4 Reach Length: 69.7

Indicators of in-channel changes	Yes	No	Photo/Field Note References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?			Banks obscured by logging slash			
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?	X			4 vs.	23	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?			Substrate obscured by logging slash			
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X		Other than at culvert area at downstream end of reach, channel substrate was obscured by slash.	24 vs.	9 (at culvert inflow)	
5. Are there changes in woody debris?						
Increase in large WD?	X			5 vs.	24	
Increase in small WD	X				(All photos)	
Decrease in WD?		X				
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?		X				

BMP Effectiveness Rating: Indeterminate

Summary:

This reach, located upstream of the newly constructed road, was initially intended to serve as a control reach for the PS-03 survey on the same type 4 stream below the road crossing. Because the area in the vicinity of the reach was harvested before follow-up surveys were conducted, this survey reflects a before-after evaluation of timber harvest effects. The area of the reach was clearcut between the 1993 and 1994 surveys, and no buffer was left on the type 4 stream. Large amounts of logging slash was left within the stream channel, which obscured many portions of the channel, making photo comparison between survey years difficult. Sediment delivery in the area of the culvert inflow was documented in the form of fresh sediment deposits. The sediment deposited at the culvert inflow may have originated at the road prism and was delivered via ditches to the culvert inflow, or the sediment may have originated within the harvested area due to channel and bank disturbance. Other than at the vicinity of the culvert inflow, the channel bed and banks were obscured by logging slash at most of the photo points, and the 1994 photos were over-exposed, so it is not possible to make an adequate evaluation of channel substrate and lower stream bank conditions with photo comparisons. The survey did document stream valley wall erosion due to mechanical disturbance in the upper portion of the study reach.

Road BMP Effectiveness Summary

Study Site:	W-03: Train Whistle - New Road Construction				
		BMP Effectiveness Ratings			
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings	Relief	Cutslopes	Fillslopes
		WAC 222-24-040	WAC 222-24-025	WAC 222-24-030	
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition:				
	CC-01	Not Effective	Effective		
	Cutbank/Fillslope:				
	CF-01			Effective	Effective
Case Narrative:	Relief culverts did not deliver sediment to streams over the 21-month monitoring period following road construction, and are rated effective. Channelized and overland flow sediment transport distances downslope of relief outfalls ranged from less than 1 meter to 20 meters. Areas downslope of the outfalls of some relief culverts was armored with rock riprap, which apparently prevented channelization. At stream crossing culverts, although portions of some fills were armored with riprap, an increasing trend in the extent of erosion on culvert fills was observed at all crossings. In the initial culvert condition survey conducted soon after road construction, erosion was rated none to slight at all stream crossings (BMPs included grass-seeding with hydromulch treatment). However, five of the six crossings had severe erosion on either the inflow or outflow side of the culvert fill 21 months following road construction. Some of the increase in erosion at stream crossing fills was attributable to disturbance of fills during logging and slash clean-up. It was noted that four of the six culvert outfalls were hanging above the streambed at elevations of 0.3 to 0.5 meters. Cutslopes on a segment draining to one of the stream crossings were highly exposed and actively eroding one year following road construction, but there was no evidence of cutslope material being delivered to the stream over the monitoring period. Delivery to the stream of eroded cutslope material was avoided by the use of rock riprap in the ditch, which prevented ditch erosion and acted to filter ditch flows and store cutslope material at the toe of the slope. Fillslope BMPs were rated effective because, although continuing to erode, fillslopes delivered only in the immediate vicinity of the stream crossing, where a gully developed during the first year following road construction.				
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:				
	CS-01A	Not Effective			
	CS-02A	Not Effective			
	Photo Point:				
	PS-01	Not Effective			
	PS-03	Not Effective			
Case Narrative:	The channel condition survey results reflect a before/after comparison of in-stream conditions for two type 4 stream reaches affected directly by placement of culverts and fills as well as the stream segment immediately downstream of the road. Photo point survey results reflect changes over the first 11 months following road construction in the same streams, from the culvert outfall to about 70 meters downstream. In addition to the loss of physical stream channel integrity and aquatic habitat function attributable to culvert and fill placement covering about 20 meters on each stream, the survey results reflected degraded stream channel conditions in the reaches downstream of the road crossing. Changes observed included increased streambed mobility, both increases and decreases in in-stream woody debris, and increases in fine sediment deposition, including more or less continuous deposits of fresh sediment extending about 60 meters below the two road crossings. The majority of this sediment delivery is attributable to chronic erosion of the large culvert fills, including slumps which developed on the outflow sides, while lesser amounts are attributable to erosion from the harvest area upstream of the road.				
	OVERALL SITE BMP EFFECTIVENESS RATING:	NOT EFFECTIVE	EFFECTIVE	EFFECTIVE	EFFECTIVE

Train Whistle Culvert Condition Survey Results

Site: W-03: Train Whistle
Survey: Culvert Condition Survey CC-01

Survey dates: 9/93 & 5/95
Date of Construction: 8/93

Site BMP Effectiveness Rating:
Stream X-ing: Not effective
Relief: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Year 1993	1994	1995	Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-1	Inflow	None		Slight	129m	Increase	Y	20m sed. transport in ditch constructed below outfall.	No	Yes
Relief	Outflow	None		Moderate	(129m)	Increase	Y			
C-2	Inflow	None		Severe	145m	Increase	Y	n/a	Yes	No
T-4, x-ing	Outflow	None		Moderate	(101m)	Increase	Y			
C-3	Inflow	None		Moderate	80m	Increase	Y	n/a	Yes	No
T-4, x-ing	Outflow	None		Slight	(131m)	Increase	Y			
C-4	Inflow	Slight		Severe	156m	Increase	Y	n/a	Yes	No
T-5, x-ing	Outflow	None		Slight	(135m)	Increase	Y			
C-5	Inflow	None		Severe	291m	Increase	Y	n/a	Yes	No
T-5, x-ing	Outflow	Slight		Slight	(289m)	Increase	Y			
C-6	Inflow	None		Severe	99m	Increase	Y	Yes, 15M down slope	No	Yes
Relief	Outflow	None		Slight	(67m)	Increase	Y			
C-7	Inflow	None		Severe	75m	Increase	Y	No	No	Yes
Relief	Outflow	Slight		Severe	(36m)	Increase	Y			
C-8	Inflow	Slight		Slight	21m	Constant	Y	n/a	Yes	No
T-5, x-ing	Outflow	Slight		Severe	(111m)	Increase	Y			
C-9	Inflow	Slight		Severe	105m	Increase	Y	n/a	Yes	No
T-5, x-ing	Outflow	None		Slight	(45m)	Increase	Y			
C-10	Inflow	Slight		Severe	40m	Increase	Y	No	No	Yes
Relief	Outflow	Slight		Severe	n/a	Increase	Y			

Comments/ Notes:

The length of road surveyed was 1,141 meters with an average culvert spacing of 114 meters. The average road gradient was 6 % with a range of 2 to 13 %. At the time of the 1993 survey, the unit had not been clearcut, and grass was growing vigorously on some areas of the road, including the ditches leading to culvert inflows and the fillslopes at culvert locations, primarily at stream crossings. These areas appeared to have been hydromulched, and very little evidence of erosion was noted. Armoring effectiveness was rated good at 5 locations, fair at 4, and poor at 11. Culvert plugging ranged from 0% to 40%, with 3 relief culverts and 3 crossings noted as 0% plugged during the 1995 survey. In 1995, the unit had been clearcut and the road had been subjected to two winters. The relief culverts were rated effective because sediment was not delivered to surface waters over the 21 month post-construction monitoring period. However, despite the grass seeding and hydromulching, revegetation was patchy and sparse in May of 1995. Erosion of fills at the stream crossings ranged from slight to severe, with some gullying and slumping of fill material, indicating chronic sediment delivery to the type 4 and 5 streams. At the time of the 1995 survey, fills at stream crossings had soil pedestal formation indicating 1-3 cm. of seasonal surface erosion, and the large fills at C3 and C4 had minor slumping to a depth of approximately 0.2 m.. The surface of some fills had been rocked, apparently in an attempt to control gullying and slumping. Obvious fresh deposits of fine sediment were observed in streams below culverts C2, C3, C4, and C5. During in-stream surveys conducted in July 1994, it was noted that there were more or less continuous deposits of fresh fine sediment covering the streambed for about 60 meters downstream of the outfalls of C2 and C3. The ground immediately below some relief culvert outfalls was armored with rock, and this apparently prevented channelization below the outfalls. In some areas, ditches were also rocked, while in some of the ditches which weren't rocked, gullying was noted. Some of the initial revegetation of ditches, fills, and culvert inflow areas had been lost by 1995, apparently due to disturbance during logging and slash clean-up.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Train Whistle
Survey Id #'s	CF-01
Survey Dates	9/1/93 & 7/28/94
Water Type	5
Road Construction Date:	8/93

Length of Road Draining to Stream: 210 meters (1 side only)

Range Road Gradient	5-11 %
Average Road Gradient	8 %
Range Hillslope Gradient	11-50 %
Average Hillslope Gradient	26 %
Range Cutslope Gradient	33-55 deg.
Average Cutslope Gradient	44 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	0		0	
% Observations w/med. slope height	100		100	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	0	0	0
% Observations w/26-50 % exposed soils	0	0	39	20
% Observations w/51-75 % exposed soils	0	0	22	7
% Observations w/76-100 % exposed soils	100	100	39	73
% Observations w/Evidence of Erosion	0	100	15	100
Evidence of Erosion w/delivery to surface water	no	no	no	Only at culvert fill
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	no	no	yes (@ culvert fill)
BMP Effectiveness Ratings:	**Effective**		**Effective**	

COMMENTS:

The forest practices evaluated with this survey were new road construction practices for cut and fill slope construction in a road segment draining to a type 5 stream crossing. The timber harvest unit accessed by the road was cut between the 1993 and 1994 surveys. Impacts from the harvesting and slash clean-up activities, including equipment rutting, timber yarding, and other mechanical disturbance to the cutslope, fillslope, and ditch were apparent during the 1994 survey. At the time of the 1993 survey, the immediate area surrounding this type 5 crossing, including the fillslopes and approximately twenty meters of the ditchline, had grass cover well established (apparently from a hydromulch treatment), but the remainder of the road segment had bare slopes. The ditch had been armored with rock riprap. Despite considerable mechanical disturbance during harvest to the cutslopes and fillslopes within the contributing drainage area to the type 5 stream, sediment delivery via the cutslopes and ditch was not evident in either survey year, based on residual evidence of flow or sediment transport in the ditch (ditch gullies, sediment plumes, etc.). However, road maintenance activities and slash clean-up following timber harvest may have obscured such residual evidence in the ditch, which was noted to be filled with road surfacing rock and cutslope ravel material in both the 1993 and 1994 surveys. The cutslopes were continuing to erode and ravel as evidences by storage of eroded material at the toe of the cutslope. While the potential exists for suspended sediment delivery to the stream during major runoff events, the riprap and ravel deposits in the ditch appeared to have prevented gully erosion in the ditch and facilitated in-ditch sediment storage, thereby alleviating chronic sediment delivery to the stream from this drainage segment. A gully which developed on the culvert fillslope between the 1993 and 1994 surveys delivered sediment to the stream, but otherwise the fillslopes did not deliver.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Train Whistle W-03

Treatment Survey ID#: CS-01A & CS-02A — Water Type: 4
Control Survey ID#: n/a — Water Type: n/a

BMP(s) Evaluated: New Road Construction: Stream Crossings

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-01A	CS-02A		There were no control reaches for this evaluation.	
Pre-Treatment Surveys:	45	43	5/13/93		
Post-Treatment Survey #1:	7	9	7/27-28/94		
Change from Pre-Treatment Score:	-38	-34			
Net Change (Control-Treatment):	n/a	n/a			

BMP EFFECTIVENESS RATING: NOT EFFECTIVE

Case Narrative:

These surveys were conducted on two type 4 streams crossed by culverted road crossings, downstream of the new road. They are on the same streams and downstream of the CS-01B and CS-02B survey reaches in the harvest unit upstream of the road. The pre-treatment surveys were conducted on reaches that were downstream of the flagged P-line for the road alignment. After road construction it was determined that the study reaches were directly impacted by the placement of the culverts and fill. Therefore, these surveys reflect a before-after comparison of stream channel changes resulting from culvert and fill placement, as well as the stream segment immediately downstream of the road crossing. In addition to the loss of stream channel integrity associated with culvert placement, stream channel changes downstream of the culvert outfall include severe bank disturbance, fine sediment deposition, destabilization of sediment storage elements, and loss of in-channel woody debris.

In-Stream Photo Point Survey Summary

Site: Train Whistle　　Survey dates: 9/8/93 & 7/27/94
Survey Id: PS-01　　Treatment Reach (no Control comparison)
Water Type: 4　　Reach Length: 67.1 meters

Indicators of in-channel changes	Yes	No	Photo/Field Note References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?		X		1 vs.	11	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		9 vs.	22	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X			5 vs.	17	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X			5,8,9 vs.	13,17,20,23	
5. Are there changes in woody debris?						
Increase in large WD?		X		9 vs.	22	
Increase in small WD	X					
Decrease in WD?	X					
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?		X		all photos		

BMP Effectiveness Rating: Not Effective

Summary:

Photo survey PS-01 was conducted below a newly constructed road that crossed the type 4 stream using culvert/fill construction techniques. Due to heavy brush and differences in photo perspectives between survey years, most of the photos were not directly comparable. The photos showing the streambed substrate that were comparable depicted extensive fresh, bright fine sediment deposits in the stream during the 1994 survey, associated with erosion of the large culvert fill placed at this crossing. Some of the sediment may also have come from hillslope and channel erosion from the clearcut harvest in the vicinity of the PS-02 survey reach above the road. The fresh sediment deposition was more or less continuous along the reach in 1994, whereas in the 1993 survey, conducted within weeks of the road construction, the streambed had a mixture of darker substrate composed of fines, gravels, and cobbles.

In-Stream Photo Point Survey Summary

Site: Train Whistle   Survey dates: 9/8/93 & 7/27/94
Survey Id: PS-03   Treatment Reach (no Control comparison)
Water Type: 4   Reach Length: 22.2 meters

Indicators of in-channel changes	Yes	No	Photo/Field Note References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?						
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?						
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X				16	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X				13,14,16	
5. Are there changes in woody debris?						
Increase in large WD?	X					
Increase in small WD						
Decrease in WD?						
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?						

BMP Effectiveness Rating: Not Effective

Summary:

Photo point survey PS-03 was conducted on a reach downstream of the newly constructed road, on a different type 4 stream from that surveyed in PS-01 and PS-02. This PS-04 study reach in the harvest unit is on the same stream upstream of the new road. The 1993 survey consisted of only one photo due to the extremely dense riparian vegetation that obscured the stream channel, making point-by-point photo comparisons between the two years impossible. However, photos and notes taken during the 1994 survey document numerous fresh, bright fine sediment deposits within the stream reach. Possible sources of this fine sediment include erosion of the large culvert fill (slumping of fill material into the stream was observed), road prism erosion delivered to the stream via ditches, or from erosion in the harvest area upstream of the road, which was clearcut between the 1993 and 1994 surveys. Unambiguous bright, fresh sediment deposition was observed to extend at least 60 meters downstream of the culvert.

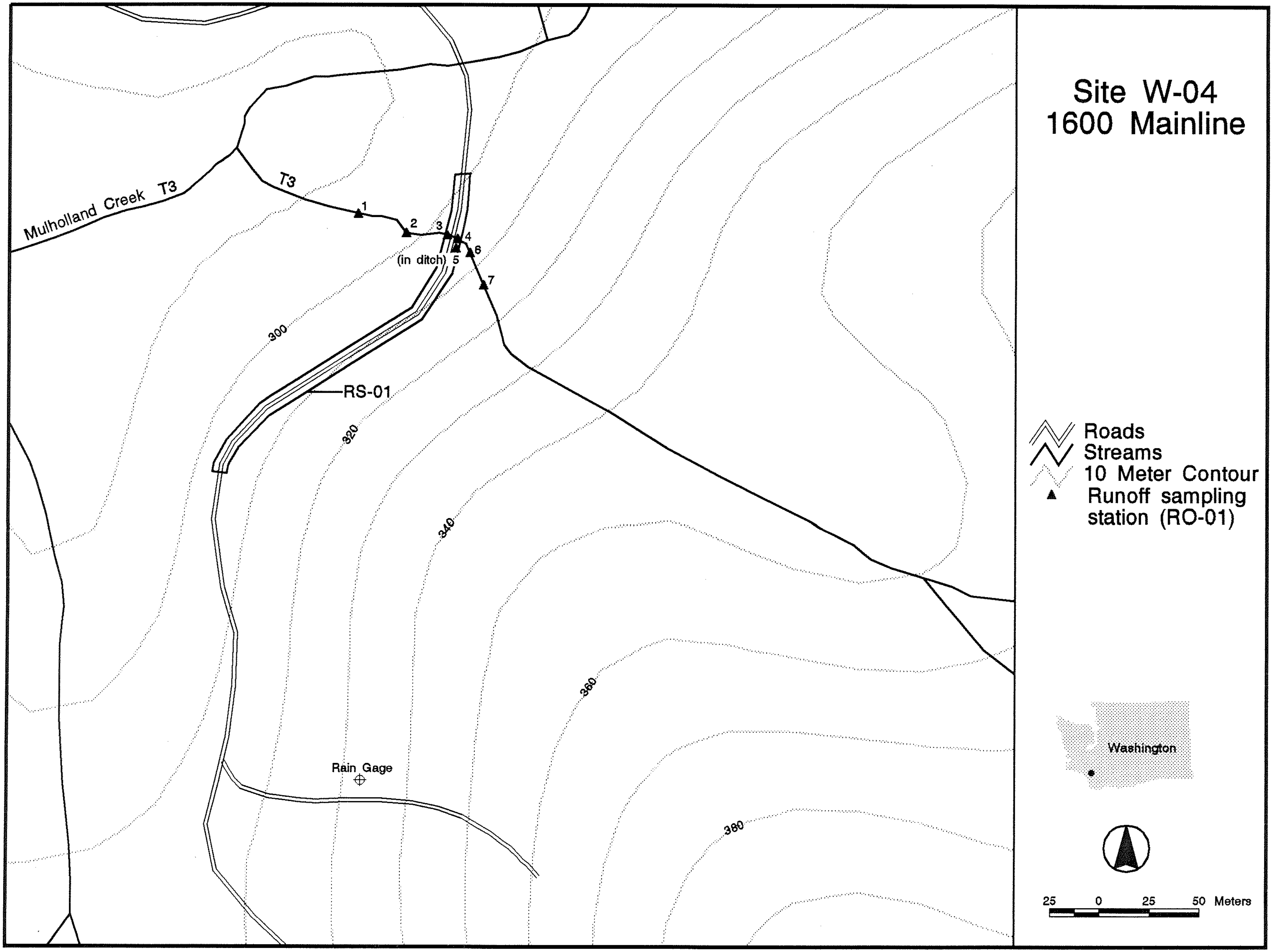
Site W-04: 1600 Mainline

The 1600 Mainline site is an active haul road located near Hemlock Pass, approximately 4 km east-southeast of the Train Whistle study site, in north-central Cowlitz County in the Willapa Hills physiographic region. The underlying geology of the site 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.

A 1st order, Type 3 tributary to Mulholland Creek is crossed by the mainline haul-road at our study site. (This stream is mis-classified as a Type 4 on the DNR Water Type map.) Mulholland creek is a tributary to the Coweeman River.

Active, mainline haul road maintenance BMPs were evaluated at this site. The road drainage segment for the stream crossing surveyed included 403 meters of mainline road plus drainage from 189 meters of a spur road. Road maintenance schedules varied according to traffic volume, weather conditions, and road-surface integrity. During preliminary field reconnaissance surveys ditch cleaning was observed for a ditch draining into the Type 3 stream.

Channel condition surveys were conducted above and below the road to evaluate in-stream sediment sources and comparability of the study reaches. A single runoff event was sampled in December 1994 using runoff sampling and road surface condition surveys.


Site W-04
1600 Mainline
Roads
Streams
10 Meter Contour
Runoff sampling station (RO-01)
Washington
25 0 25 50 Meters
Mulholland Creek T3
T3
1
2
3
4
5
6
7
(in ditch)
RS-01
300
320
340
360
380
Rain Gage

Active Haul Road Maintenance BMP Effectiveness Summary

Study Site:	W-04: 1600 Mainline Road	
	Survey Employed	**BMP Effectiveness Ratings** Active Haul Road Maintenance WAC 222-24-050(2) & (4)
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Road Surface Condition Survey: RS-01	Effective
Case Narrative:	The road segment surveyed was the near-stream portion of a drainage segment that included 403 m of mainline road plus 189 m of drainage from a spur road. This road segment was surveyed during a single runoff event during December 1994. Weather conditions during the survey were characterized by intermittent light rain. The on-site rain gauge recorded a cumulative total of 1.5 mm falling over 4.5 hours during the 7-hour precipitation monitoring period. However, runoff on the road surface and in ditches was observed. Measurements of fines on the road surface and other observations of road surface conditions were indicative of a well-maintained gravel-surfaced road. The thickness of fines on the road surface was less than 0.5 cm. in the center of the road, and generally 1-3 cm along the edges of the travelway. No rutting or rilling of the road surface was apparent. Ditchlines and cut and fill slopes were well-vegetated nearest the stream, but there was a 35 m segment where a 15m high cut slope was actively eroding. The majority of the sampled segment was outsloped or crowned, with berms nearest the stream, but some sections were insloped. Traffic on the day of sampling included 36 heavy vehicles (6 loaded log trucks, and 12 unloaded log trucks and other heavy trucks) and 26 light vehicles over a 6.5 hour period.	
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Runoff Sampling: RO-01	Effective
Case Narrative:	Water sampling indicated transport of colloidal fines in ditches, with turbidity as high as 800 NTU during times of rainfall, falling to 210 NTU during an afternoon lull in the rain. Total suspended solids concentrations in the ditch flow were also elevated in the morning but not in the afternoon. There was no discernible effect of this road drainage on either turbidity or total suspended solids concentrations in the stream, based on results from sampling above and below the road. Ambient conditions in the stream upstream of the road were characterized by 11-12 NTU, while below the road crossing and in the mixing area for the ditch discharge (on the immediate upstream side of the road), turbidity was 10-13 NTU. TSS concentrations in the morning were at 14 mg/l upstream and 13-16 mg/l downstream, while in the afternoon they ranged from 15-16 mg/l upstream and 14-17 mg/l downstream. This indicates potentially stressful ambient conditions based on the aquatic life stress index of Newcombe and MacDonald (1991), but no impacts from this road segment during the light runoff conditions monitored. Stream discharge measurements taken on the day of sampling indicated that streamflow downstream of the road was the same or slightly less than upstream. Our stage height recorder showed that streamflow was steady throughout the monitoring period, varying by no more than 1 cm, confirming that this was a relatively minor runoff event.	
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE

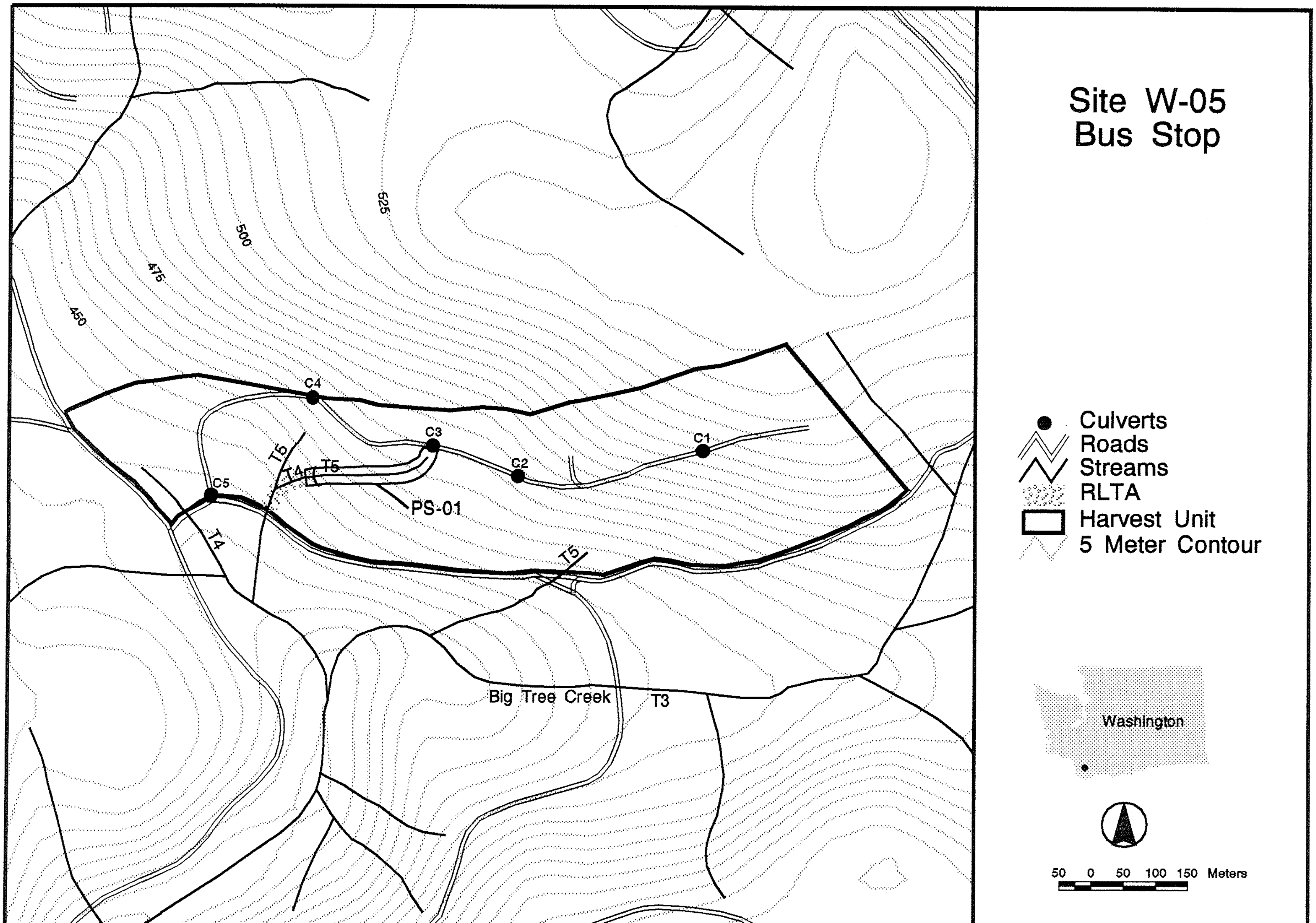
Site W-05: Bus Stop

This is a road construction evaluation site located in northeastern Clark County in the Willapa Hills physiographic region. The underlying geology of the site is Miocene-aged basalt and basalt-andesite lava flows. Soils at the site are classified as Newaukum cobbly silt loam, 5-30% slopes in most of the area of new road construction, and Cinebar silt loam, 3-8% slopes along stream valleys. Both soils have soil hazard ratings of stable for disturbed soil stability, with cutbank/fill/sidecast hazard and erosion potential rated moderate and medium, respectively. The road construction BMP slope hazard category for the site is low, with hillslope gradients less than 20% at drainage swale crossings.

The road crosses drainage swales above the channel heads of two zero order Type 5 tributaries to Big Tree Creek in the Lewis River basin. These streams flow through a harvest unit that was clearcut the year following road construction, and join to form a Type 4 which was buffered with an RLTA.

Forest practices conducted at this site include 1.2 km of new road construction. The entire length of new road construction is within the boundaries of a 32 hectare clearcut. The harvest unit is rectangular in shape with the road traversing the northern section of the unit. The road construction was completed in June 1993. Harvest was completed by the summer of 1994.

BMPs evaluated at the Bus Stop study site were the new road design and construction practices, specifically those for installing relief culverts, including drainage relief in swales draining to the Type 5 streams. Surveys employed at this site included a culvert condition survey conducted in September 1993 and September 1994 and a photo point survey conducted in October 1993 and September 1994. The purpose of the photo point survey was to monitor sediment transport in the swale and the condition of the channel head and stream below the road, in terms of road drainage effects. While the timing of timber harvest activities interfered somewhat with the in-stream evaluation, harvest BMPs were not targeted for evaluation at this site.



Site W-05
Bus Stop
Culverts
Roads
Streams
RLTA
Harvest Unit
5 Meter Contour
Washington
50 0 50 100 150 Meters
525
500
475
450
C1
C2
C3
C4
C5
PS-01
T3
T4
T5
T6
Big Tree Creek

Road BMP Effectiveness Summary

Study Site:	W-05: Bus Stop - New Road Construction				
			BMP Effectiveness Ratings		
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings	Relief	Cutslopes	Fillslopes
		WAC 222-24-040	WAC 222-24-025	WAC 222-24-030	
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition: CC-01		Effective		
Case Narrative:	Practices for relief culverts at this site are rated effective because relief culverts did not deliver sediment to streams over the 15-month monitoring period following road construction. Sediment transport distances downslope of relief outfalls ranged from less than 1 meter to 8 meters. Two of the four relief culverts were located in un-channelized drainage swales, approximately 40-80 meters above type 5 channel heads. Practices employed at this site which likely contributed to the lack of downslope sediment transport included large sediment traps at one of the culverts and the use of rock riprap in the ditch leading to the relief culvert that was in closest proximity to a stream.				
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Photo Point: PS-01		Effective		
Case Narrative:	The photo point survey was employed to evaluate sediment transport in a swale below a relief outfall and road drainage effects on a type 5 stream that began 42 meters downslope of the road. Although the area was clearcut harvested between the initial and follow-up surveys, it was ascertained that there was virtually no evidence of road sediment being transported through the swale, nor was upslope migration of the stream channel head observed over the monitoring period.				
	OVERALL SITE BMP EFFECTIVENESS RATING:		EFFECTIVE		

Bus Stop Culvert Condition Survey Results

Site: W-05: Bus Stop
Culvert Condition Survey CC-01
Survey Dates: 9/93 and 9/94
Date of construction: 6/93

Site BMP Effectiveness Rating:
Stream X-ing: n/a
Relief Culverts: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year 1993	Extent of Erosion Survey Year 1994	Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-1, Relief	Inflow	None	Moderate	164m	Increase	Y		No	Yes
	Outflow	Slight	Slight	(164m)	Constant	Y	Yes, 8m down slope		
C-2, Relief	Inflow	None	Slight	317m	Increase	Y		No	Yes
	Outflow	None	Slight	(97m)	Increase	Y	No		
C-3, Relief	Inflow	None	Slight	108m	Increase	Y		No	Yes
	Outflow	None	Slight	(108m)	Increase	Y	Slight, 1m down slope		
C-4, Relief	Inflow	None	Slight	215m	Increase	Y		No	Yes
	Outflow	None	Slight	(215m)	Increase	Y	No		

Comments/ Notes Summary:

The average distance between culverts was 243 meters, with average road gradient of 7.4%. Armoring effectiveness for both the inflows and outflows was rated as "Poor" or "Fair", with most receiving a "Poor" rating. Plugging of culvert inflows was noted in 1993 shortly after road construction(C1 and C2 were 35% and 40% plugged). However, at the time of the 1994 survey, all the relief culverts were observed to be 0% plugged. Between culverts 1 and 2, a spur road breached the cutslope, blocked the ditch, and forced water to flow down the surface of the road toward the fillslope. Apparently recognizing the potential erosion problem this situation created, the operators constructed a berm on the edge of the road near the fillslope which directed the water to the outflow at culvert 2. The inflow at culvert 2 had been mechanically excavated and was functioning as an effective sediment trap. A second, larger sediment trap was constructed at the outflow of culvert 2. The ditch between culverts 2 and 3 was effectively armored with rock. Culvert 3 drains to a swale leading to the type 5 study stream. There was no evidence of sediment delivery to the type 5 or channel initiation below the outflow of culvert 3, in fact, there was no evidence that the swale had carried surface flow during the course of the study. Sediment traps were not constructed at C3, but a large slash pile was left just downslope of the outfall. Culvert 4 was also placed in an un-channelized drainage swale above a type 5 stream in the same drainage as the type 5 below C3. As in the case of C3, there was no evidence of channelization or sediment transport down the swale. Practices for relief culverts at this site are rated effective because drainage relief discharges did not deliver sediment to streams over the 15-month monitoring period following road construction, despite the fact that two of the relief culverts were located in un-channelized drainage swales, approximately 40-80 meters above type 5 channel heads. Sediment transport distances downslope of relief outfalls ranged from less than 1 meter to 8 meters. Practices employed at this site that likely contributed to the lack of downslope sediment transport included large sediment traps at one of the culverts and the use of rock riprap in the ditch leading to the relief culvert that was in closest proximity to a stream.

In-Stream Photo Point Survey Summary

Site: Bus Stop W-05

Survey dates: 10/8/93 and 9/22/94

Survey Id: PS-01

Treatment Reach (no Control comparison)

Water Type: 5, changing to type 4

Reach Length: 182 meters

Indicators of in-channel changes	Yes	No	Photo/Field Notes References (Pt. #, Frame#) 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks? *Caused by timber harvest activities, not road effects.	X*					
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?						
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?						
4. Is there evidence of increased deposition or storage of fine or coarse sediment? **No evidence of road sediment routing to or depositing in the stream.		X**				
5. Are there changes in woody debris? Increase in large WD? Increase in small WD Decrease in WD? ***Increase in SWD from logging slash.	X***					
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?						

Summary:

This survey was conducted to monitor for effects from road drainage that might be discharged from a road drainage relief culvert installed in the un-channelized swale above the stream. The stream channel began 42 meters downslope of the culvert outfall. Although the area was clearcut harvested between the two survey years, which changed the character of the stream and made point-to-point photo comparisons impossible, it was ascertained that there was no sediment delivery from the road drainage to the stream over the monitoring period, nor was there upslope migration of the channel head in response to road drainage. There was little to no evidence of sediment transport of surface runoff in the swale below the relief culvert.

BMP Effectiveness Rating: Effective

Site W-06: Pot Pourri

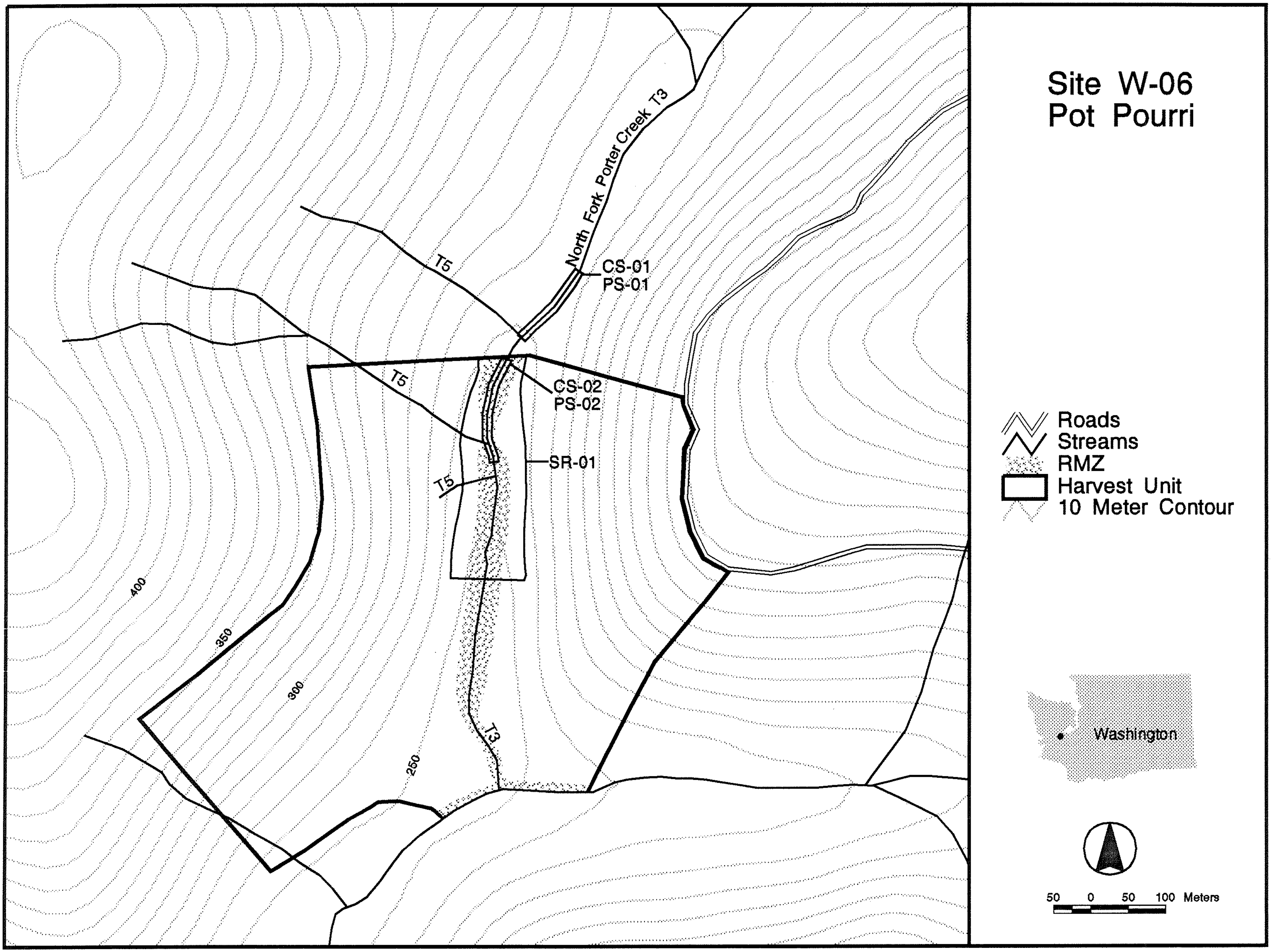
The Pot Pourri site is a harvest practice evaluation located in western Thurston County within the Capitol State Forest in the Willapa Hills physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The underlying geology is Eocene-aged volcanic rock of submarine basalt flows and flow breccia. Soils at the site are classified as Boistfort silt loam, 20-40% slopes and Wadell silty clay loam, 0-3% slopes. The disturbed soil slope stability rating for both soils is stable, with soil hazard ratings for cutbank/fill/sidecast road construction and erosion potential of moderate and medium, respectively, for the Boistfort soil, and an erosion potential rating of low for the Wadell soil. The harvest BMP slope hazard category is high, with stream valley side slopes of up to 58% along the study reach.

The harvest unit is traversed by North Fork Porter Creek, a 3rd order Type 3 stream that is a tributary to the Chehalis River. Porter Creek has a pool-riffle channel morphology in a wide-alluviated valley. Active channel width along the treatment reach is 6 meters with an average channel gradient of 2%. There are two Type 5 tributaries to Porter Creek in the portion of the harvest unit evaluated. These tributaries were un-typed on the DNR Water Type maps.

Forest practices conducted at this site include a 33 hectare clearcut harvest with 1.9 km of road construction of which about 0.5 km are within the harvest unit. The harvest unit covers both sides of Porter Creek, which was buffered with a RMZ. The width of the RMZ averaged 17 meters in the survey area. The harvest was conducted using cable-yarding and was completed in February 1994.

The BMPs evaluated at this site are the RMZ along Porter Creek with adjacent cable harvesting. Two study reaches were established on Porter creek. The treatment reach is within the RMZ while the control is located upstream of the harvest unit boundary. Both reaches were evaluated using channel condition and photo point surveys, with surveys conducted in May 1993, April 1994, and June 1995. Stream amphibian surveys were conducted within the treatment reach by investigators from the University of Washington, as part of the CMER Wildlife-RMZ research project. Sediment routing surveys were conducted in September 1994 and June 1995.

Site W-06
Pot Pourri



Harvest BMP Effectiveness Summary

Study Site: W-06: Pot Pourri - Clearcut harvest with RMZ

	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01		Effective				
Case Narrative:	Application of RMZ practices at this unit were effective at preventing direct sediment-related water quality impacts to the Type 3 stream. There was short-term sediment delivery to the Type 3 stream from one yarding feature, and indirect delivery via unbuffered tributaries. It was noted that cable yarding at this unit was accomplished with minimal ground disturbance, apparently due to good log suspension. Although sediment effects in unbuffered Type 4/5 waters was not specifically evaluated at this study site, disturbance of a Type 5 stream/wetland area and delivery of sediment to another Type 5 stream was observed. Within the sediment routing survey area, delivery from harvest-related erosion features was not chronic; harvest erosion features which delivered had re-vegetated by the time of the follow-up survey.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-02/CS-01		Effective				
	Photo Point: PS-02/PS-01		Effective				
Case Narrative:	Only minor changes were noted in the treatment reach relative to the control during the first year following harvest, including some increase in the deposition of fines in pools. Between the first and second post-harvest stream surveys, a bed -mobilizing flow event affected both treatment and control reaches, resulting in increased streambed mobility and sediment deposition. This flow event resulted in the blowout of a large beaver dam just downstream of the study reaches. Residual effects from the logging of the original forest were noted in both treatment and control reaches, including cull logs within and adjacent to the stream.						
	OVERALL SITE BMP EFFECTIVENESS RATING:		EFFECTIVE				

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site:	Pot Pourri	Survey Date(s)	9/6/94 & 6/27/95
Site ID #	W-06	Survey ID #	SR-01
Water Type	3, 5	Months Since Harvest	7 & 16

9/6/94 Survey Summary:

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no	20.7	25-50	7.8
2	yarding	no	8.0	50-75	5.0
3	yarding	no	4.7	25-50	1.8
4	yarding	no	5.6	0-25	0.7
5	falling	no	2.5	25-50	0.9
6	yarding	yes	9.8	0-25	1.2
7	yarding	no	11.9	50-75	7.4
8	falling/yarding	yes	71.3	25-50	26.7
9	in-stream deposit	n/a	(surface area: 3.6 m^2)	n/a	n/a
10	yarding	no	60.5	0-25	7.6
11	yarding	yes	11.9	0-25	1.5
	TOTALS	3 delivered	206.9		60.6

Total Area of Ground Surveyed = 2.7 hectares

Total Length of Stream Bank Surveyed = 762 meters

Disturbed Soil per Hectare = 76.6 m^2/ha

Area Exposed Soil per Hectare = 22.4 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 29.4 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 10.9 m^2/hectare

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 29.4 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 10.9 m^2/hectare

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	8	33.0	2.7	9.2
falling	1	0.9	0.0	0.0
falling/yarding	1	26.7	26.7	90.8

NARRATIVE:

The RMZ established on the type 3 water (Porter Creek) was effective at preventing sediment delivery directly to Porter Creek with the exception of one erosion feature (disturbance caused by tree falling and yarding identified as feature 8). The remainder of the features which delivered to surface waters were delivering to unbuffered type 4/5 tributaries to Porter Creek, just upstream of where they entered the RMZ. One of the erosion features # (6) located on a type 5 tributary to Porter Creek was located upstream of a sediment deposit within the creek identified, as feature # 9. This sediment deposit was located on the edge of the Porter creek floodplain. 27 % of the features identified delivered to surface waters. 100 % of the features that delivered were within 10 meters of the surface water. The features that delivered account for 49 % of the total area of exposed soil surveyed.

6/27/95 Survey Summary

Survey Date: 6/27/95

NARRATIVE:

A follow-up survey was conducted 16 months following timber harvest, focusing on those features that were delivering sediment to surface waters in the initial survey. The second year survey was limited to only that side of the RMZ that had features which delivered the previous year. None of the three yarding and falling features that had delivered sediment in 1994 were doing so in 1995. They had revegetated to the point that they were no longer considered to be erosion features. The sediment deposit from the type 5 stream which had settled in the Porter Creek floodplain was still present, but had decreased in size. A single erosion feature, which delivered to Porter Creek, was identified in 1995. This feature is a wildlife trail which had been noted as the route of delivery to Porter Creek from feature number 8 in the 1994 survey. This wildlife trail was 5 m^2 of disturbed soil, 0-25% exposed. Feature number 8 was a falling and yarding scar that, as mentioned, had revegetated to the point that it no longer met the minimum size criteria for an erosion feature.

BMP EFFECTIVENESS RATING:

RMZ (Cable Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Pot Pourri W-06

Treatment Survey ID#: CS-02 Water Type: 3
Control Survey ID#: CS-01 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut with Cable Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	62	5/19/93	62	5/19/93
Post-Treatment Survey #1:	58	4/28/94	60	4/28/94
Change from Pre-Treatment Score:	-4		-2	
Net Change (Control-Treatment):	-2			
Post-Treatment Survey #2:	56	6/27/95	55	6/27/95
Change from Pre-Treatment Score:	-6		-7	
Net Change (Control-Treatment):	+1			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
The net decrease in the treatment reach score noted in the first post-treatment surveys resulted primarily from increased fines in pools. More substantial changes were noted in both study reaches between the first and second post-treatment surveys, including increases in fresh sediment deposits, increased bed mobility, and unstable sediment storage elements composed of small woody debris. These changes are indicative of a bed-mobilizing peak flow event, which is further indicated by the blow-out of a large beaver dam which was located approximately 90 meters downstream of the treatment reach between the 1994 and 1995 surveys. It was noted that beavers had become active in the treatment reach in 1995. The Sediment Routing survey indicated some delivery of sediment was likely during the initial 7 months following timber harvest via the type 4/5 tributaries on the right bank side of the unit, but areas of exposed soil were not extensive and did not persist into the second year following harvest. Channel morphology of both treatment and control reaches is such that they are susceptible to fines deposition, as well as destabilization of streambanks. Survey observations documented residual effects of logging of the original forest, including large cull logs functioning as LWD within and adjacent to the channel. It was also noted that the RMZ appears to have prevented any direct disturbances of the stream bed and banks. Windthrow was low within the RMZ along the treatment reach, with only two downed spruce observed over the 2 year study period; no recent windthrow was observed along the control reach. The overall observations of channel condition indicates that any localized effects on the Type 3 stream due to the harvest were none to minimal during the evaluation period.

In-Stream Photo-Point Survey Comparison Summary

Site: Pot Pourri

Survey Years: 5/93, 4/94, & 6/95

Study Reach Descriptions: 141 m. treatment reach on type 3 stream; control reach is 120 m. on same stream, upstream of harvest unit.

Indicators of in-channel changes	Control PS-01 Yes	Control PS-01 No	Treatment PS-02 Yes	Treatment PS-02 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X		X
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X		X
5. Are there changes in woody debris? * 3 new windthrown trees down across the channel in treatment reach.				
Increase in large WD?		X	X*	
Increase in small WD?		X		X
Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X		X

Summary:

Only minor changes were noted in either the control or treatment reach. Many of the photographs showed that even some of the small woody debris had not moved between the survey years. Large woody debris appeared stable, with only one piece having moved, and that was in the control reach. Windthrow within the RMZ during the second winter following timber harvest resulted in 3 new trees down across the channel along the 141 meter treatment reach.

BMP Effectiveness Rating: Effective

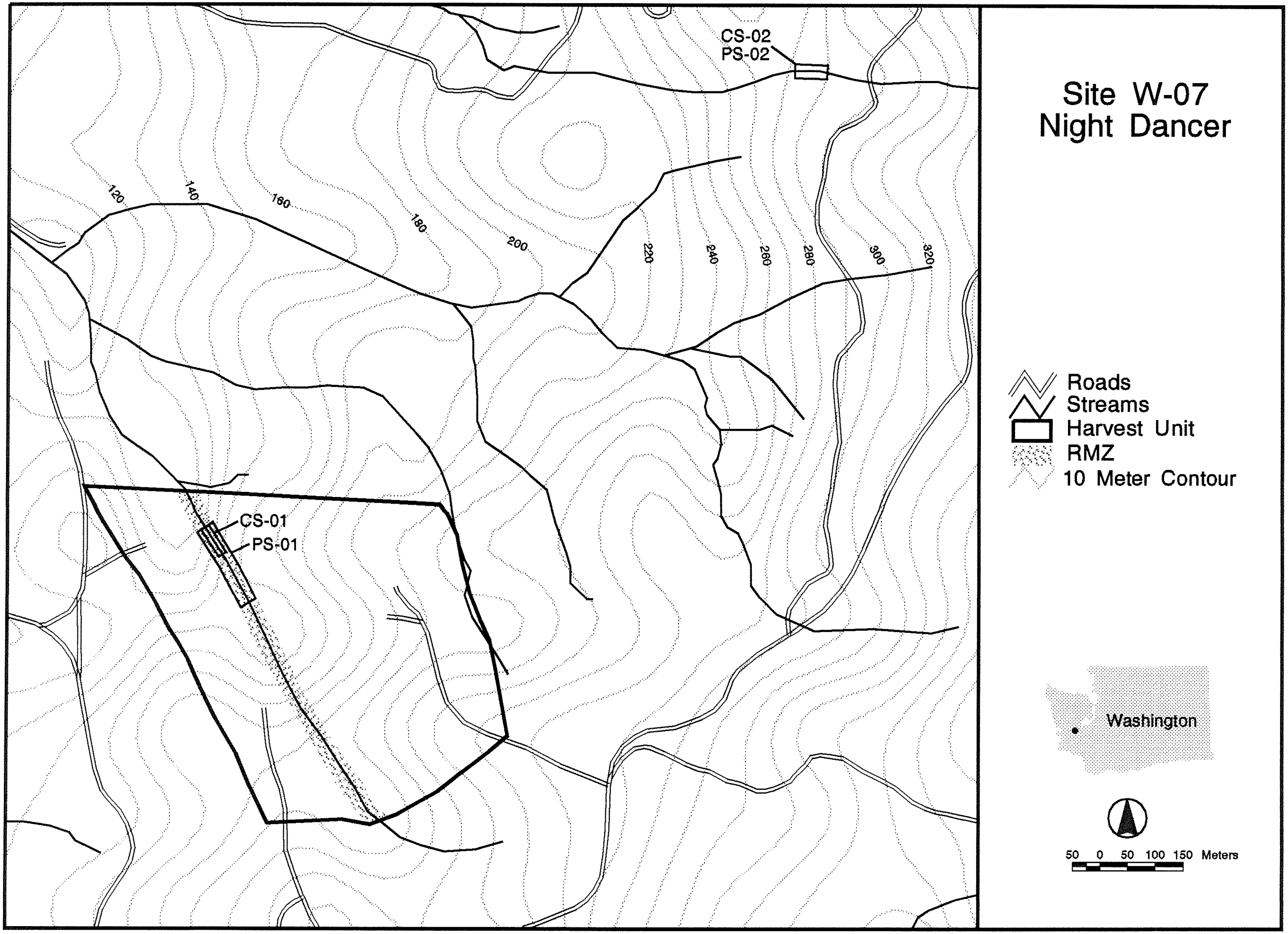
Site W-07: Night Dancer

The Night Dancer site is a harvest practice located southeast Grays Harbor County, within the Capitol State Forest in the Willapa Hills physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The underlying geology consists of Eocene-aged volcanic rock 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 part of the harvest unit classified as Boisfort silt loam, 8-30% slopes. Both soils have a disturbed slope stability rating of stable, and cutbank/fill/sidecast and erosion potential hazard ratings of moderate and medium, respectively. The harvest BMP slope hazard category is high, with stream valley side slopes ranging from 29% to 46%.

The study stream at this site is a 1st order tributary to Porter Creek which flows into the Chehalis River near the town of Porter. This stream segment was depicted as a Type 5 on the DNR Water Type map, however it meets the physical criteria for a Type 3 water, and was treated with a standard regulation RMZ for the purpose of the wildlife-RMZ study. The stream has step-pool channel morphology, with an active channel width of 4 meters and an average gradient of 9%.

Forest practices conducted at this site include a 38 hectare clearcut harvest conducted using cable-yarding, 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 study stream, with no road access across the stream within the unit. An RMZ was established on both sides of the stream. Although originally planned to occur in 1993 or 1994, the harvest was delayed at this site and was not completed until March 1995.

The BMPs evaluated at this site are the RMZ along the stream with adjacent cable harvesting. A study reach was established on the stream within the harvest unit, and a control reach was established outside of the unit on a different Type 4 tributary to Porter Creek, located about 1 km to the northeast. Channel condition surveys were conducted on both study reaches in May 1993 and May 1995, and photo point surveys were conducted on both reaches in June 1993 and May 1995. Stream amphibian surveys were conducted within the treatment reach by investigators from the University of Washington, as part of the CMER Wildlife-RMZ research project.


Site W-07
Night Dancer
Roads
Streams
Harvest Unit
RMZ
10 Meter Contour
Washington
50 0 50 100 150 Meters
CS-02
PS-02
CS-01
PS-01
120
140
160
180
200
220
240
260
280
300
320

Harvest BMP Effectiveness Summary

Study Site: W-07: Night Dancer - Clearcut harvest with RMZ

		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	While no sediment routing or other erosion/delivery surveys were conducted to evaluate this harvest practice, it was noted in post-harvest stream surveys that fresh deposits of fine sediment were evident at the mouth and lower section of an unbuffered Type 5 tributary to the treatment reach. There was no evidence of yarding across the RMZ within the study reach; timber was yarded away from the RMZ on both sides. There was no evidence of harvest of RMZ trees within the study reach, but limbing/bucking activities occurred within the RMZ. In-stream disturbance was observed where a large log apparently rolled down into the stream, as well as disturbance due to recent windthrow.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01/CS-02		Not Effective				
	Photo Point: PS-01/PS-02		Partially Effective				
Case Narrative:	While both treatment and control reaches experienced one or more bed-mobilizing flow events between pre-treatment and post-treatment surveys, in-stream surveys found greater levels of degradation in the treatment reach, where channel condition scores decreased by 35% as compared to an 8% decrease in the control reach. Changes observed included increased stream bank erosion, increased streambed mobility and destabilization of sediment storage elements (including excavation of sediment wedges associated with small woody debris), logging slash and windthrow in the channel, and increases in fresh sediment deposits in the treatment reach relative to the control reach. Photo point surveys documented the increased sediment deposition and streambed mobility, including changes in aquatic plants in the treatment reach due to scour and bed mobility, as well as evidence of increased bed mobility in the control reach. Some of the bank destabilization and sediment deposition in the treatment reach was associated with recent windthrow. The post-harvest monitoring period at this site was short (only 2-3 months) because the harvest was delayed and occurred at least one year later than originally planned.						
	OVERALL SITE BMP EFFECTIVENESS RATING:		PARTIALLY EFFECTIVE				

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Night Dancer W-07

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 4

BMP(s) Evaluated: RMZ (Clearcut with Cable Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	60	5/19/93	53	5/20/93
Post-Treatment Survey #1:	39	5/30/95	49	5/30/95
Change from Pre-Treatment Score:	-21		-4	
Net Change (Control-Treatment):	-17			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:
Substantial changes in stream channel stability were noted within the treatment reach following timber harvest activities. The net decrease in treatment reach score is primarily due to observations of: 1) increases in stream bank erosion, with windthrow and flowing water indicated as the cause of bank erosion; 2) destabilization of sediment storage elements, with recent excavation of several sediment wedges associated with SWD; 3) net increases stream bed mobility and fresh sediment deposits; and 4) a net decrease in the extent of fine sediments within the control reach. The treatment reach has a step-pool morphology with an average gradient of 9%, and is slightly braided in sections. Wet seeps were noted in the floodplain. This reach has a moderately low potential to store fine sediments, except in dammed pools and channel margin areas, which were noted as having obvious fresh deposits of fines in 1995. Fresh fines were evident in the lower section and mouth of a right bank Type 5 tributary which was unbuffered in the clear cut harvest area. Observations indicate one or more bed-mobilizing peak flow events in the treatment reach between the pre- and post-treatment surveys. Other disturbances in the treatment reach included recent windthrow of RMZ trees and a large cull log piece which rolled down into the stream. Surveyors noted that there was no evidence of yarding across or within the RMZ reach, with trees yarded away from the RMZ on both sides. There was evidence of limbing/bucking of trees within the RMZ, but no harvest of RMZ trees. It was noted in the control reach that the stream bed appeared less mobile for the larger grain sizes, relative to the treatment reach. Although less extensive than in the pre-treatment survey, a layer of fresh fines was noted in most pools and marginal areas of the control reach in 1995, attributable to one or more roads which cross the stream above the survey reach.

In-Stream Photo-Point Survey Comparison Summary

Site: Night Dancer   Survey Dates: 6/15/93 & 5/30/95

Study Reach Descriptions: 138 m. treatment reach on type 3 stream; control reach is 58 m. on a type 4 stream in a nearby drainage. Both streams are tributaries of Porter Creek.

Indicators of in-channel changes	Control PS-02 Yes	Control PS-02 No	Treatment PS-01 Yes	Treatment PS-01 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?	X	X	X	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X		X	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X	X	
5. Are there changes in woody debris? * 5 new windthrown trees down across the channel in treatment reach. 1 new windthrow across the channel in the control reach.				
Increase in large WD?	X*		X*	
Increase in small WD?	X		X	
Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X	X	

Summary:

A notable change observed in the treatment reach was the increase in both small and large woody debris from windthrow and logging slash. The contradictory calls on bank erosion in the control reach is due to the addition of one new windthrow bank feature and the revegetation of a pre-existing windthrow rootwad at the stream bank. One or more peak flow events occurred in both study reaches, mobilizing smaller substrate size classes on the streambed. Bed mobility, fresh sediment deposition, and bank erosion were more pronounced in the treatment reach than in the control. Changes noted in aquatic plants refer to a reduction of mosses on the streambed

BMP Effectiveness Rating: Partially Effective

Southern Cascades Physiographic Region

Site S-01: Camp One Road

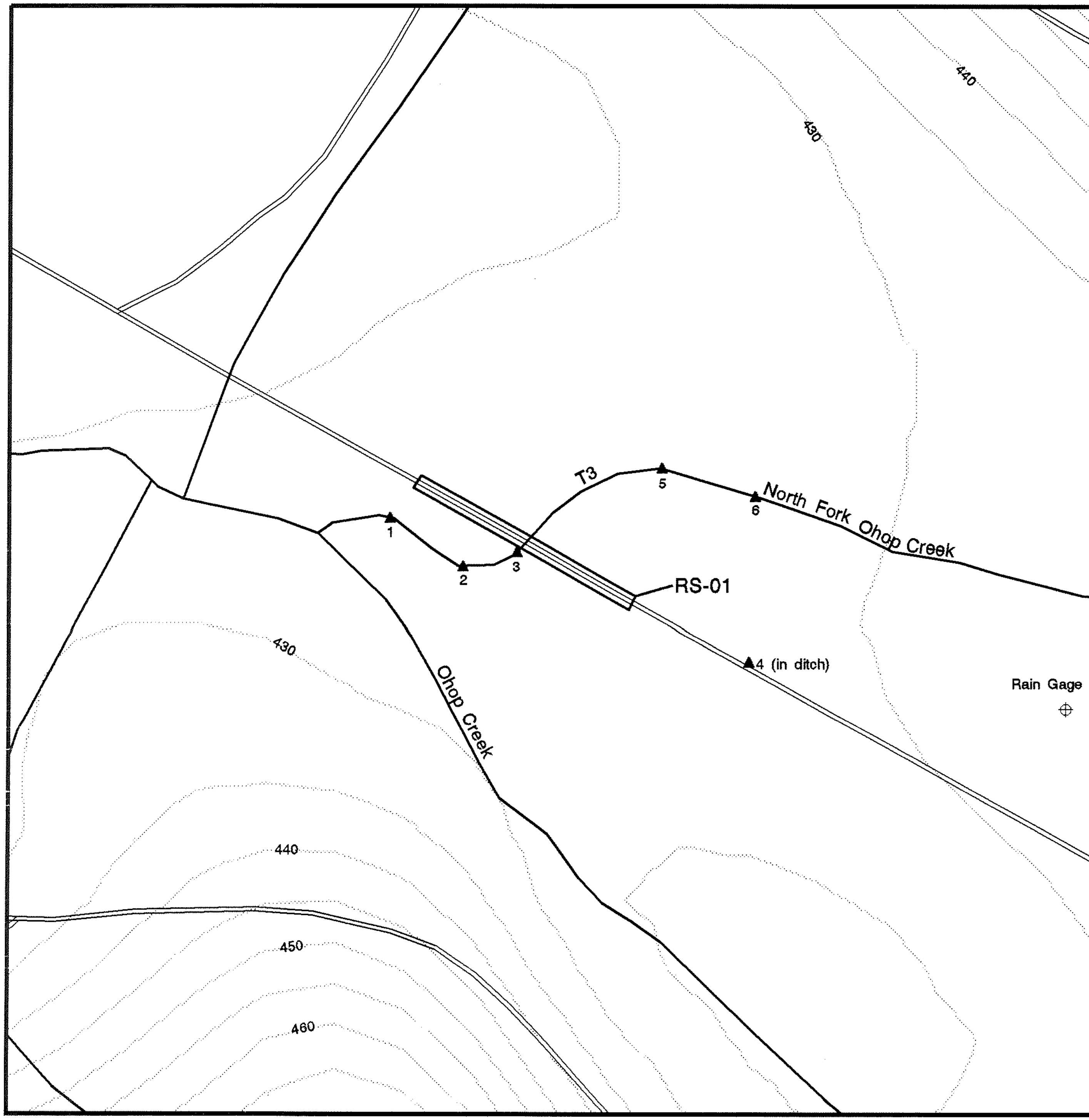
The Camp One Road site is an active haul road located in south-central Pierce County in the Southern Cascades physiographic region. The surface geology of the site is classified as unconsolidated glacial drift. Soils at the study site are classified as fluvaquents and humaquents, 0-3% slopes. These soils are rated as stable for disturbed slopes, a cutbank/fill/sidecast hazard was not assigned, and their erosion potential is low. Stream valley side slope gradients along the study reach are 5% or less.

The study stream at this site is North Fork Ohop Creek, a 2nd order, Type 3 stream that is a tributary of the Puyallup River via Kapowsin Lake. Both the control and treatment reaches have pool-riffle morphologies and average stream gradients of 2-3%.

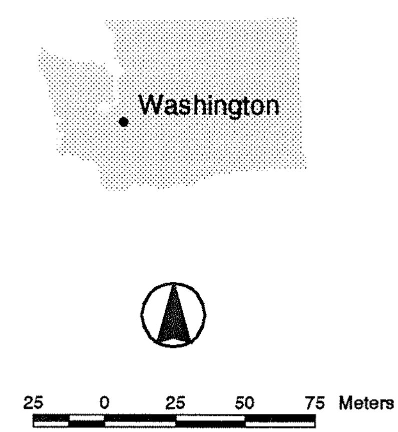
Active, mainline haul road maintenance BMPs were evaluated at this site. The road section evaluated was the near-stream portion of a flat, mainline drainage segment that included 1150 meters of road length to the nearest discernible drainage divides, with discontinuous ditch drainage. The road crosses N.F. Ohop Creek via two large parallel culverts. At the stream crossing, the road is crowned and gravel-surfaced; where present, cutslopes and ditches were well-vegetated. Maintenance schedules varied 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 the study site did not appear to occur on a regular basis; grasses and shrubs were well established to the edge of the road travel surface.

Two study reaches were established on the creek: a control reach located upstream of the road crossing, and a treatment reach located immediately downstream of the crossing. Channel condition surveys were conducted on both reaches to evaluate in-stream sediment sources and comparability of the study reaches. Runoff sampling and road surface condition surveys were conducted at the site during a light rainfall event in April 1993. Although sampling was scheduled to coincide with a rainfall-runoff event that had been forecast, there was not active runoff during the sampling. The rain gauge and stream stage recorder at the site revealed only a trace of rain and a receding hydrograph during the sampling period.

Site S-01
Camp One Road



Roads
Streams
5 Meter Contour
Runoff sampling station (RO-01)



Active Haul Road Maintenance BMP Effectiveness Summary

Study Site:	S-01: Camp One Road	
	Survey Employed	**BMP Effectiveness Ratings** Active Haul Road Maintenance WAC 222-24-050(2) & (4)
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Road Surface Condition: RS-01	Indeterminate
Case Narrative:	The effectiveness call is indeterminate because the survey results are not representative of active runoff conditions. The road segment surveyed was the near-stream portion of a very flat drainage segment that included 1150 meters to the nearest discernible drainage divides (with discontinuous ditch drainage along this length due to the flat topography), and potential drainage from portions of two spur roads. This road segment was surveyed during a light rainfall event over a two day period during April 1993, with more intense rainfall occurring during the night before the two-day sampling period. The on-site rain gauge recorded only 0.3 mm (a single tip) over a 7-hour precipitation monitoring period. Surface flow was observed in a roadside ditch, but this would best be characterized as inter-storm baseflow. Measurements of fines on the road surface and other observations of road surface conditions are indicative of a well-maintained road, with the thickness of fines on the road surface less than 2 cm (most measurements less than 0.5 cm.) in the center of the road, and generally 3-13 cm along the edges of the travelway. No rutting or rilling of the road surface was apparent. Grading of the road segment was observed the day prior to the road surface condition survey, during the runoff sampling period. Ditchlines and fill slopes were well-vegetated, and there were no cutslopes due to the flat topography of the site on a main valley floor. The sampled segment was crowned, with a ditch on one side and with berms in sections farther away from the stream. Traffic on the day of road surface sampling included 23 heavy vehicles (log trucks, dump trucks, etc.) and 15 light vehicles over a 3 hour period. On the previous day during runoff sampling there were 51 heavy trucks and 31 light vehicles over a 6-hour period.	
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Runoff Sampling: RO-01	Indeterminate
Case Narrative:	Water sampling indicated some transport of colloidal fines in the ditch, with ditch flow turbidity and total suspended solids (TSS) slightly elevated above ambient stream levels (turbidity of 5.5 to 6.5 NTU compared to about 3 NTU in the stream). TSS concentrations were elevated by about 2-4 mg/l in the ditch flow. There were no discernible effects of the road drainage on either turbidity or total suspended solids concentrations in the stream, based on sampling above and below the road. Ambient conditions in the stream upstream of the road were characterized by 2.7-3.2 NTU, while below the road crossing the turbidity was 2.0-3.0 NTU. TSS concentrations were 2-3 mg/l both upstream and downstream of the road. These results indicate no impacts from this road segment during the non-runoff, inter-storm baseflow conditions monitored. The stream stage height recorder showed that streamflow was declining throughout the monitoring period, dropping 5 cm over the 5.5 hour recording period, confirming that this was not a runoff event. Therefore, the effectiveness call is indeterminate.	
	OVERALL SITE BMP EFFECTIVENESS RATING:	INDETERMINATE

Site S-02: 8 Road Unit 2

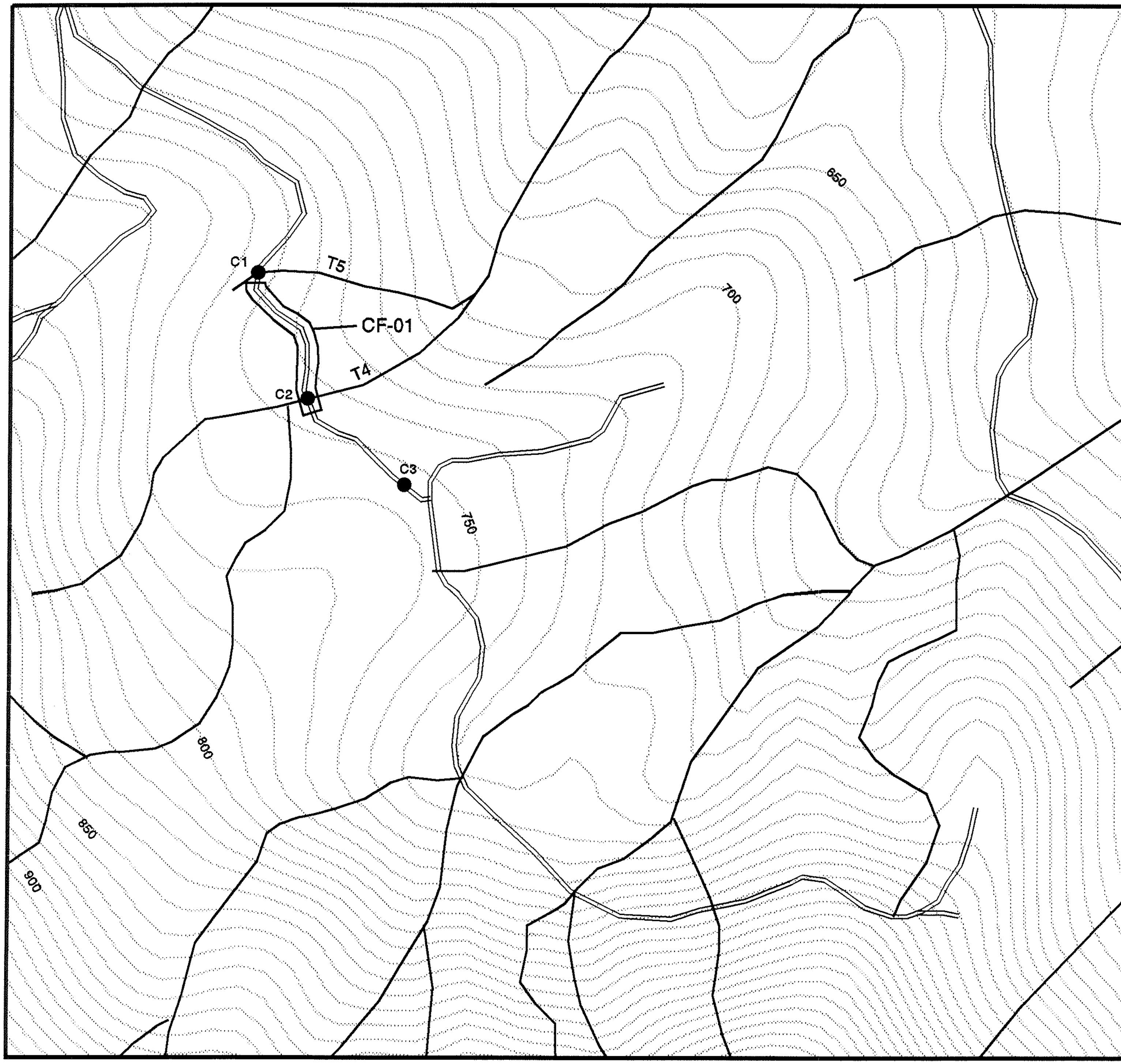
The 8 Road Unit 2 site is located in south-central Pierce County in the Southern Cascades physiographic region. New road construction BMPs were evaluated at this site. The surface geology of the area is classified as Eocene and Oligocene-aged andesite and basalt flows. Soils at the site are mapped as Jonas gravelly silt loam, 30-65% slopes. These soils are rated as stable for disturbed slopes, with a moderate hazard rating for cutbank/fill/sidecast construction, and a medium erosion potential. Based on hillslope gradients of 47-51% at the stream crossings, the road construction BMP slope hazard category for the site is high.

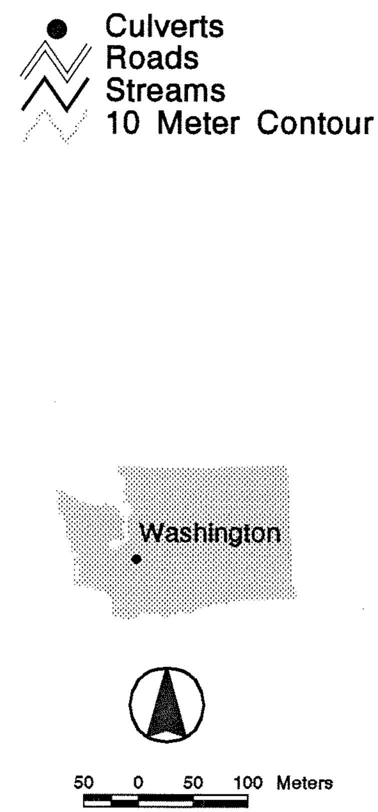
The section of new road construction evaluated crosses two streams: a 1st order Type 4 and a zero order Type 5. The Type 4 was mis-classified as a Type 5 on the FPA and DNR Water Type map. The study streams are located on the access road leading into the 8 Road Unit 2 harvest area, but are outside of the harvest unit boundary. Both streams are tributaries of Neisson Creek, in the Puyallup River basin.

Forest practices conducted at this site include approximately 2.2 kilometers of new road construction. Construction of the road segment evaluated was completed by August of 1992.

BMPs evaluated at the 8 Road Unit 2 site are the new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Culvert condition surveys that covered two stream crossings and one relief culvert along 439 meters of the road were conducted in January 1993 and May 1994. Cutbank/fillslope surveys were conducted in January 1993 and May 1994 to evaluate the segment draining to the Type 4 stream crossing.

Site S-02
8 Road Unit 2





Road BMP Effectiveness Summary

Study Site:	S-02: 8 Road Unit 2 Road - New Road Construction				
		BMP Effectiveness Ratings			
		Culvert BMPs		Road Construction BMPs	
	Survey Employed	Stream Xings	Relief	Cutslopes	Fillslopes
		WAC 222-24-040	WAC 222-24-025	WAC 222-24-030	
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition: CC-01	Partially Effective	Effective		
	Cutbank/Fillslope: CF-01			Not Effective	Effective
Case Narrative:	Culvert fills were adequately stabilized at one of two stream crossings by the second year of surveys (21 months following road construction). This was attributed to effective armoring with rock, including additional rock placed following the initial construction, combined with hydromulch and grass seeding. The relief culvert did not deliver sediment to streams by the second year following road construction, and is rated effective. The overland flow sediment transport distance downslope of the relief outfall was 30 meters. Plugging of the relief culvert following re-grading of the road was noted as a concern during second-year surveys. The fillslopes did not result in delivery of sediment except for the immediate vicinity of the culverts and are rated effective. Cutslope erosion, including gully development, did result in substantial amounts of chronic sediment delivery to the Type 4 stream via drainage ditches, as evidenced by the expanding sediment deposit in the stream. Grass seeding with hydromulch treatment of both cut and fill slopes was partially effective in controlling erosion, except where gullies developed.				
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	No separate in-stream surveys conducted.				
Case Narrative:	While no separate in-stream surveys were conducted, a sediment deposit (approx. 4 square meters in size) was documented in the Type 4 stream below the road crossing during both survey years. The source of this sediment is attributed to inadequately controlled cutslope erosion in the drainage segment. Fresh sediment deposits were also noted in the Type 5 stream, attributable to cutslope and culvert fill erosion.				
	OVERALL SITE BMP EFFECTIVENESS RATING:	PARTIALLY EFFECTIVE	EFFECTIVE	NOT EFFECTIVE	EFFECTIVE

8 Road Unit 2 Culvert Condition Survey Results

Site: 8 Road Unit 2
Culvert Condition Survey CC-01

Survey dates: 1/29/93 & 5/16/94
Date of Construction: 8/92

Site BMP Effectiveness Rating:

Stream X-ing: Partially Effective
Relief: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year		Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
		1993	1994						
C-1	Inflow	Slight	Slight	59m	Constant	Y	n/a	Yes, type-5	No
T-5 x-ing	Outflow	Slight	Slight	(75m)	Constant	Y	n/a		
C-2	Inflow	Slight	Slight	214 m	Constant	Negligible	n/a	Yes, type-4	Yes
T-4 x-ing	Outflow	Slight	Slight	(218m)	Constant	Negligible	n/a		
C-3	Inflow	None	Slight	166 m	Increase	Y	Overland flow, 30m	No	Yes
Relief	Outflow	None	Moderate	(146m)	Increase	Y	down slope		

Comments/ Notes Summary:

The average distance between culverts was 146 meters, and the road gradient ranged between 1 and 4 %, with the average being 2 %. The hill slope gradients ranged from 33-59 %. Armoring was rated as "fair" for 5 of the 6 calls in 1993 and "poor" at 1 of the 6. The culvert fills were re-armored with rock prior to the 1994 survey, with the armoring effectiveness rated as "good" at culverts 1 and 2, and "poor" at culvert 3. During the re-grading of the road between the 1993 and 1994 surveys, the armoring at the inflow to culvert 3 was covered and the inflow was badly plugged (80 %). In 1993, fresh sediment deposits were observed in the stream downstream of the outflows of culverts 1 and 2. In 1994, continuing in-stream deposition of fine sediment was noted downstream of the outflow of culvert 2, but the source of this sediment was determined to be cutslope and ditch erosion in the drainage segment rather than erosion of the culvert fill. In1994, it was noted that the ditch leading to culvert 3 was well-armored, but gullies had developed on the C3 fill as a result of road runoff. Because of the re-armoring of the fill at culvert 2, and the successful application of grass seed with hydromulch, and because of the short fill height (3m), the amount of continuing erosion and the potential for future erosion have been greatly reduced, and the BMPs employed at C2 are rated effective. The extent of chronic erosion at C3 is greater because of the greater fill height of 5m, and because the fill was only partially armored.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	8 road Unit 2
Survey Id #'s	CF-01
Survey Dates	1/29/93 & 5/16/94
Water Type	T-4
Road Construction Date:	8/92
Length of Road Draining to Stream	203 meters

Range Road Gradient	1-6 %
Average Road Gradient	3 %
Range Hillslope Gradient	33-59 %
Average Hillslope Gradient	33%
Range Cutslope Gradient	28-53 deg.
Average Cutslope Gradient	43 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	22		56	
% Observations w/med. slope height	78		44	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	44	0	100
% Observations w/26-50 % exposed soils	0	22	100	0
% Observations w/51-75 % exposed soils	0	22	0	0
% Observations w/76-100 % exposed soils	100	12	0	0
% Observations w/Evidence of Erosion	100	100	100	78
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	yes	yes
BMP Effectiveness Ratings:	**Not Effective**		**Effective**	

COMMENTS:

In 1993, the types of erosion observed included gullying, slumping, and sheetwash erosion on both cutslopes and fillslopes. Storage was occurring in the ditch for cutslopes and in the slash for fillslopes. Most of the cover for fillslopes was from slash in 1993. The road surface was rocked and graveled to a depth > 15 cm. Evidence of erosion in 1994 for both cutslopes and fillslopes was noted as minor to major gullying, slumping, soil pedestals, and sheetwash erosion. Two seeps were noted on the cutslope, one at Pt. 1 and the other between Pt. 3 and Pt. 4. Storage was noted in ditches for cutslopes and in slash on fillslopes. Grass seed and hydromulch was applied after the 1993 survey, and photos taken during the 1994 survey show extensive growth on previously exposed soils on both cutslopes and fillslopes. However, despite grass seeding, the gullies which formed on the cut and fillslopes prior to the 1993 survey were continuing to erode, and in the case of the cutslope gullies, they are sources of chronic sediment delivery to the stream via the drainage ditch. A fresh sediment wedge at the outflow to culvert C-2 was observed in both 1993 and 1994. The surface area of the deposit was 2 square meters in 1993 and 4 square meters in 1994. Newly placed rip-rap was noted at the outflow to the culvert (C-2) during the 1994 survey.

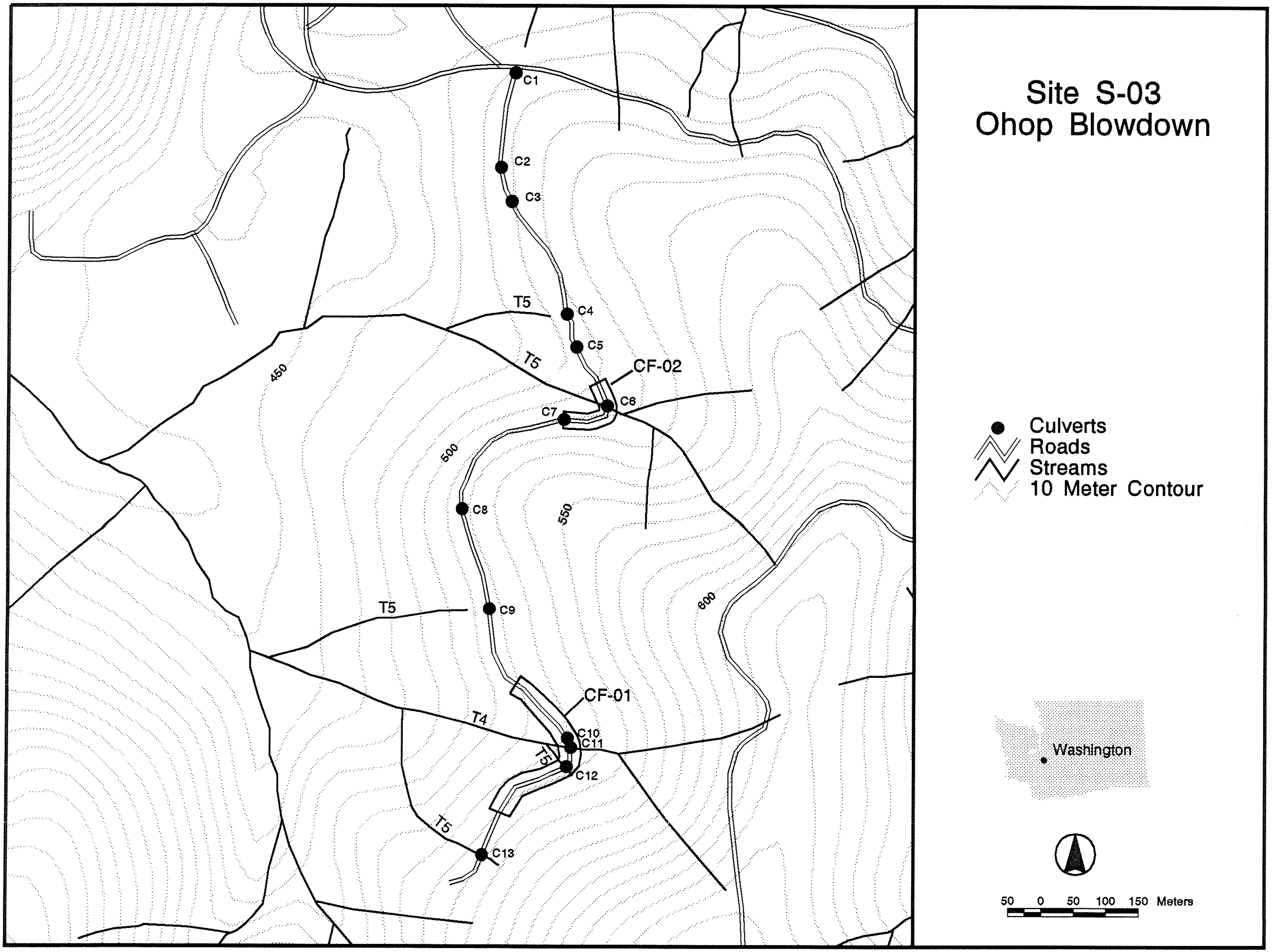
Site S-03: Ohop Blowdown

The Ohop Blowdown site is located in south-central Pierce County in the Southern Cascades physiographic region. New road construction BMPs were evaluated at this site. The surface geology of the site is classified as Eocene and Oligocene-aged andesite and basalt flows. Soils at the site are mapped as Jonas gravelly silt loam, 30-65% slopes, and Scamman silt loam, 6-15% slopes. Both soils are rated as stable for disturbed slope stability, with a moderate cutbank/fill/sidecast hazard, and a medium erosion potential. Based on hillslope gradients of up to 55% in the vicinity of stream crossings, the road construction BMP slope hazard category for the site is high.

The new road construction crosses three Type 5 streams and one Type 4 stream, which are zero order tributaries to Twenty-five Mile Creek. Twenty-five Mile creek is a tributary of Ohop Creek in the Nisqually River basin.

Forest practices conducted at this site include approximately 1.8 kilometers of new road construction. Road construction was completed by September of 1992. Following road construction, a portion of the site was clearcut harvested, but harvest BMPs were not targeted for evaluation at this study site.

BMPs evaluated at the Ohop Blowdown site are the new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Culvert condition surveys that covered four stream crossings and nine relief culverts along 1,756 meters of the road were conducted in February 1993 and May 1994. Cutbank/fillslope surveys were conducted in February 1993 and May 1994 to evaluate two drainage segments, one of which included the Type 4 stream crossing and a crossing of a short Type 5 stream that began as a hillslope seep just above the roadcut location, and one that included another Type 5 crossing.


Site S-03
Ohop Blowdown
Culverts
Roads
Streams
10 Meter Contour
Washington
50 0 50 100 150 Meters
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
CF-01
CF-02
T4
T5
450
500
550
600

Road BMP Effectiveness Summary

Study Site:	S-0: Ohop Blowdown				
		BMP Effectiveness Ratings			
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings	Relief	Cutslopes	Fillslopes
		WAC 222-24-040	WAC 222-24-025	WAC 222-24-030	
	Culvert Condition:				
ASPECT 1:	CC-01	Partially Effective	Effective		
Effectiveness in terms of chronic erosion with delivery to surface waters.					
	Cutbank/Fillslope:				
	CF-01			Not effective	Effective
	CF-02			Effective	Effective
Case Narrative:	Relief culverts did not result in channel initiation (except for one short, 3 meter channel below C2) or delivery of sediment to streams, and are rated effective. Chronic erosion and sediment delivery was documented at all stream crossings, but at three of the four crossings the extent of erosion had decreased to slight levels by the second spring following road construction. Stream crossing practices were effective at these three culverts, which were well-armored with rock riprap to prevent/minimize erosion. At another crossing of a type 5 stream originating at a seep just upslope of the road, culvert fill erosion continued at moderate to severe levels into the second spring, and increased channel development was evident below the crossing. The fillslopes did not result in delivery of sediment except for the immediate vicinity of stream crossings culvert fills, and are rated effective. Cutslope erosion did result in chronic sediment delivery to the Type 4 stream via ditches draining to the crossing at culvert C11 (survey CF-01). Slash and sidecast was also observed in the stream in the vicinity of the crossing in the CF-01 survey. In addition to surface wash and slumping of cutslope material, a seep flowed across and eroded the cutslope between C11 and C12, and cutslope failure at another seep just upslope of C12 produced sediment which was routed down the ditch. In all, seven seeps were observed along the cutslope within the CF-01 survey. In the case of the CF-02 survey, although observations of chronic erosion included minor gullying and slumping along the cutslopes, microtopography associated with a bedrock outcropping and a low-gradient section of ditch functioned effectively as natural sediment trap, which apparently encouraged infiltration of ditch flow, and preventing direct delivery of sediment to the stream. No seeps were noted along the CF-02 road segment, and there was no residual evidence of ditch flows continuing ton the crossing.				
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	No separate in-stream surveys were conducted.				
Case Narrative:	Stream impacts observed during road surveys included sediment deposition in the type 4 stream at culvert C11, attributed to cutslope erosion within the drainage segment and sidecast material from the culvert fill, and accelerated channel erosion observed in a type 5 stream downstream of culvert C12. At the four crossings of type 4 and 5 streams, culvert outfalls were hanging at elevations of 0.3 to 1.3 meters above the streambed.				
	OVERALL SITE BMP EFFECTIVENESS RATING:	PARTIALLY EFFECTIVE	EFFECTIVE	PARTIALLY EFFECTIVE	EFFECTIVE

Ohop Blowdown Culvert Condition Survey Results

Site: S-03: Ohop Blowdown
Culvert Condition Survey CC-01

Survey dates: 2/93 & 5/94
Date of Construction: 9/92

Site BMP Effectiveness Rating:

Stream X-ing: Partially Effective
Relief: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year		Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
		1993	1994						
C-1	Inflow	None	None	n/a	None	No	No	No	Yes
Relief	Outflow	None	Slight	(n/a)	Increase	Yes			
C-2	Inflow	Moderate	Slight	139m	Decrease	Yes	Yes, channel 3m down slope	No	Yes
Relief	Outflow	Slight	Slight	(100m)	Constant	Yes			
C-3	Inflow	None	None	58m	None	No	No	No	Yes
Relief	Outflow	None	None	(253m)	None	No			
C-4	Inflow	None	slight	219m	increase	Yes	No	No	Yes
Relief	Outflow	None	Slight	(35m)	Increase	Yes			
C-5	Inflow	None	None	61m	None	No	No	No	Yes
Relief	Outflow	None	Slight	(126m)	Increase	Yes			
C-6	Inflow	None	None	118m	None	No	n/a	Yes**	Yes
Type-5, x-ing	Outflow	Slight	Slight	(127m)	Constant	Negligible			
C-7	Inflow	slight	None	82m	Decrease	No	No	No	Yes
Relief	Outflow	Slight	Slight	(253m)	Constant	Yes			
C-8	Inflow	None	None	253m	None	No	No	No	Yes
Relief	Outflow	None	Slight	(154m)	Increase	Yes			
C-9	Inflow	Severe	Moderate	154m	Increase	Yes	No	No	Yes
Relief	Outflow	Moderate	Slight	(100m)	Decrease	Yes			
C-10	Inflow	Moderate	None	249m	Decrease	No	No	No	Yes
Relief	Outflow	Moderate	Slight	(149m)	Decrease	Yes			
C-11	Inflow	Severe	Slight	24m	Decrease	Yes	n/a	Yes**	Yes
Type-4, x-ing	Outflow	Severe	Slight	(70m+)	Decrease	Yes			
C-12	Inflow	Severe	Severe	46m	Constant	Yes	n/a	Yes	No
Type 5 x-ing	Outflow	Severe	Moderate	(93m)	Decrease	Yes			
C-13	Inflow	Severe	Slight	223m	Decrease	Yes	n/a	Yes**	Yes
Type-5, x-ing	Outflow	Severe	Slight	n/a	Decrease	Yes			

** Amount of chronic sediment delivery from slight levels of fill erosion at these culverts is considered negligible due to short (<3m) fill heights and/or effective armoring with riprap.

Culvert C6 was the stream crossing in cutbank/fillslope survey CF-02
Culverts C10, C11, and C12 were included in cutbank/fillslope survey CF-01.

Ohop Blowdown Culvert Condition Survey Results

Comments/ Notes Summary:

The length of road surveyed was 1,756 meters, with an average culvert spacing of 135 meters. The average road gradient was 7 % with a range of 1-14 %, and the hillslope gradient along the road alignment in two drainage segments averaged 37 % and 39%, with a range of 11-55 %. Armoring effectiveness in 1994 was rated as "good" for most of the culverts with only culverts 9 and 12 receiving "poor" ratings for the outflow and inflow, respectively. Relief culverts 4 and 9 were both located upslope of type 5 streams, however no sediment delivery was documented at either location. The outflows of culverts 6 and 7 were partially crushed by rocks used to armor the fillslopes. Culvert 8 did not appear to relief any drainage because of its placement at the centerline of a ridge. The type 5 stream was observed to be flowing through the fill, under the pipe at culvert 6. The culvert fill at C6 was almost completely armored with rock, which minimized the potential for chronic erosion of the culvert fill. By 1994, a sediment deposit located at the outflow of culvert 9 had revegetated with grasses. The inflow to culvert 10 was 40 % plugged by sediment which slumped off the cutslope between the 1993 and 1994 surveys, which diverted flow to the ditch leading to the stream crossing at culvert 11. Between culverts 11 and 12 is a flowing seep that was diverted down the ditch to culvert 11. The intended function of C12 may have been to relieve ditch flow, but it was actually placed at the head of a small type 5 seep/stream, where it appears to have increased channel development downstream of the culvert and delivered sediment via the type 5 stream to the type 4 stream crossed by C11. Due to a slump on the cutslope and sediment deposits at the inflow, culvert 12, like culvert 10, does not provide complete flow relief for the ditch, and some of the ditch drainage bypasses the inflow and drains to the crossing at culvert 11. The type 5 water that is crossed by culvert 13 is a tributary to the type 4 at culvert 11. Channelization was not observed downslope of relief outfalls, with the exception of a 3 meter channel developed below C2, but subsurface flow was apparent during the 1994 survey downslope of several relief culvert outfalls. Portions of the road were crowned (only partially draining to the ditch), which may have helped prevent channelization from relief outfalls by reducing ditch flows. Also, there was extensive slash in the clearcut areas below some relief culverts, which may have promoted flow dissipation and infiltration of drainage relief discharges.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Ohop Blowdown
Survey Id #'s	CF-01
Survey Dates	2/2/93 & 5/17/94
Water Type	T-4
Road construction date;	9/92
Length Road Draining to Stream	306 meters

Range Road Gradient	1-16 %
Average Road Gradient	9 %
Range Hillslope Gradient	19-48 %
Average Hillslope Gradient	39%
Range Cutslope Gradient	30-53 deg.
Average Cutslope Gradient	42 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	40		40	
% Observations w/med. slope height	60		60	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	13	0	73
% Observations w/26-50 % exposed soils	7	27	100	27
% Observations w/51-75 % exposed soils	7	27	0	0
% Observations w/76-100 % exposed soils	86	33	0	0
% Observations w/Evidence of Erosion	100	100	100	100
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gully Development or Mass Wasting on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	yes
BMP Effectiveness Rating:	**Not Effective**		**Effective**	

COMMENTS:
In 1993, evidence of erosion for cutslopes were noted as small slumps and large slumps (Pt. 3 to Pt.4), with a type-5 seep/stream flowing across the cutslope between observation points P6 and P7. This type-5 flows to culvert C-12 between Pt. 6 and Pt. 7. There are three culverts within this survey; one at Pt. 9 (culvert C-11) which drains the type 4 study stream to which the CF-01 drainage segment drains, one between Pt. 6 and Pt. 7 (culvert C-12) which provides a crossing for the type 5 seep/spring and partially relieves ditch flow on the south side of C11, and culvert 10 (C10) which partially relieves the ditch on the north side of C11. In 1993, surface erosion was the primary erosion process observed. Slash and sidecast material were observed in the Type-4 stream. In 1994 erosion on cutslopes ranged from minor sheetwash erosion to major slumping. This major slumping occurred at the Type-5 seep, with direct delivery occurring from this slump. Other evidence of erosion included soil pedestals, tension cracks, and minor slumping. These other forms of erosion were also noted for the fillslopes. the delivery from fillslopes was from the areas surrounding the culvert. Seven different seeps were noted along the cutslope side of the road, which may have contributed to a failure (slump) of the cutslope near the inflow to C11. Evidence of storage for cutslopes ranged from none, to storage in the ditch and on the road surface. Sediment eroded from fillslopes was documented being stored in the slash. Between survey points 13 and 14, the fillslope was used as a landing and subsequently burned. The burned area was not found to be a source of sediment to streams.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Ohop Blowdown
Survey Id #'s	CF-02
Survey Dates	2/16/93 & 5/18/94
Water Type	T-5
Road construction date	9/92
Length of Road Draining to Stream	127 meters

Range Road Gradient	1-12 %
Average Road Gradient	7 %
Range Hillslope Gradient	18-55 %
Average Hillslope Gradient	37%
Range Cutslope Gradient	30-50 deg.
Average Cutslope Gradient	40 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	40		40	
% Observations w/med. slope height	60		60	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	20	40	100
% Observations w/26-50 % exposed soils	20	40	20	0
% Observations w/51-75 % exposed soils	0	40	0	0
% Observations w/76-100 % exposed soils	80	0	40	0
% Observations w/Evidence of Erosion	100	100	100	83
Evidence of Erosion w/delivery to surface water	no	no	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	minor
BMP Effectiveness Ratings:	**Effective**		**Effective**	

COMMENTS:
In the 1993 survey, the cutslopes were noted as being un-vegetated except for small areas where the new road paralleled an old RR grade. The surface of the fillslopes consisted of soil, rock, and logging slash. The Type-5 stream crossing (culvert C-6) was adjacent to a bedrock out-cropping, that had been shot for the placement of the road. Shot rock was used as armoring for the culvert fill, some of which deposited in the active channel of the Type-5 stream during placement. In 1994, evidence of erosion for cutslopes was noted as tension cracks, sheetwash erosion, minor gullying, and slumping. Sediment storage occurred on the road surface and in the ditch. Several points were noted as not storing sediment. For fillslopes, similar erosion features were noted. Storage was noted in slash and in the blasted material placed on culvert C-6's fillslope. Four seeps were noted between survey points 7 and 12. On the left bank side of the stream crossing, immediately up-gradient from the bedrock outcrop, there is a low-gradient section of the drainage ditch that facilitated dissipation of energy from ditch flows and aided infiltration. Acting as a fortuitous topographic "sediment trap" formed by the bedrock outcrop, this area, in combination with a crowned or partially outsloped road design, appeared to have effectively prevented surface runoff from the cutslope and ditch from delivering to the stream at the crossing. On the right bank side of the stream, there was little to no residual evidence of surface flow in the ditch, indicating that a lack of concentrated flow, a low gradient in the ditch, and soil infiltration prevented eroded material from being delivered to the stream.

Site S-04: Friday Creek II

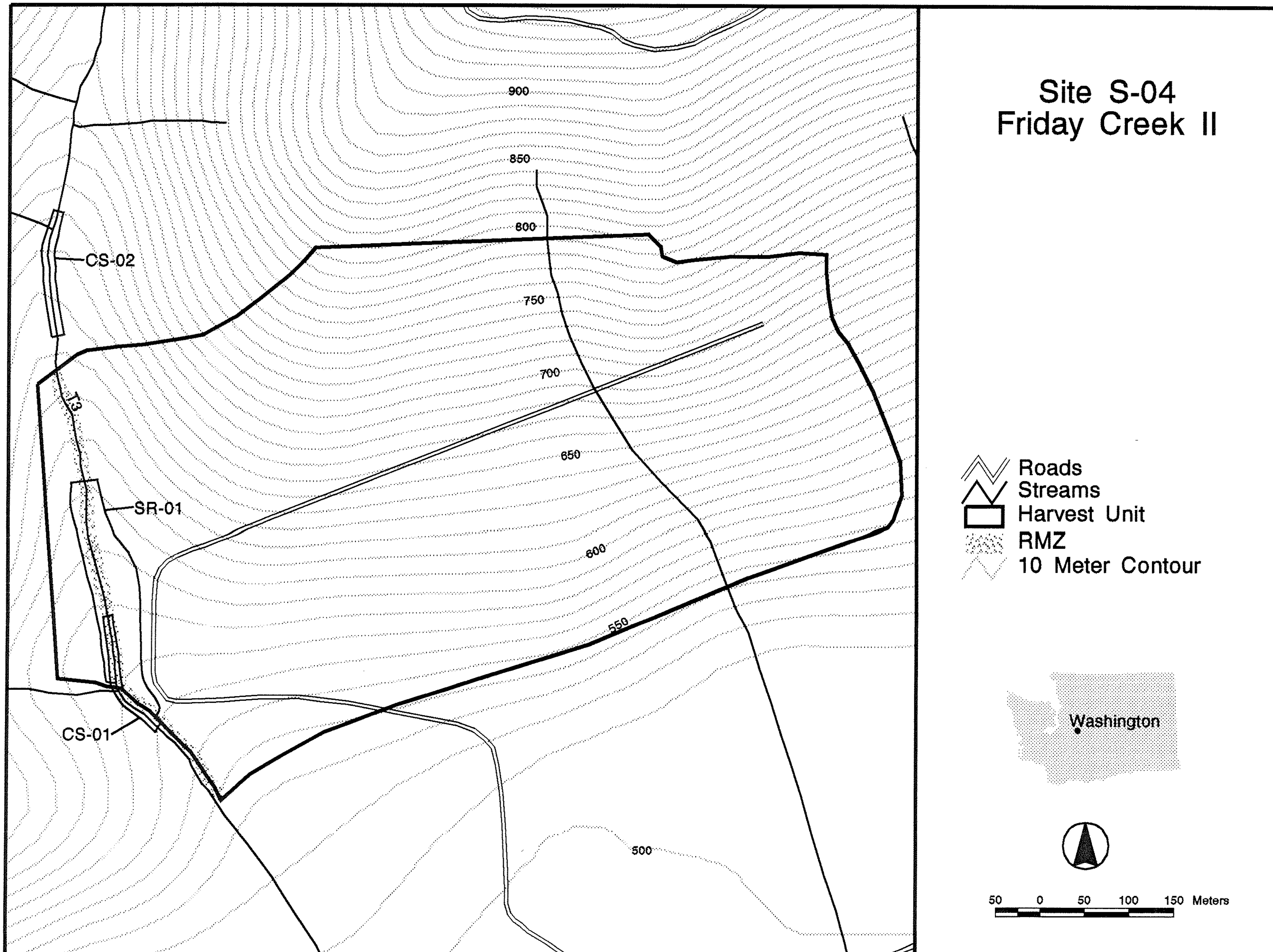
Friday Creek II is a harvest practice evaluation site located in southeast King County in the Southern Cascades physiographic region. The surface geology of the area is classified as Eocene and Oligocene-aged andesite, basalt breccia, and tuff. Soils at the study site are mapped as Pitcher sandy loam and exposed breccia substratum, 30-65% slopes. These soils are rated as unstable for disturbed slope stability, with a severe cutbank/fill/sidecast hazard and a medium erosion potential. Based on valley side slope measurements taken along the study stream, the harvest BMP slope hazard category for the site is high, with slope gradients ranging from 44-48% adjacent to the stream.

The study stream at this site is a 2nd order, Type 3 stream that is a tributary to the Green River. The treatment reach within the harvest unit has a cascade/step-pool channel morphology with a V-shaped valley. The average active channel width is 8 meters, with an average gradient of 11%.

Forest practices conducted at this site include a 23 hectare clearcut with a RMZ established along the Type 3 study stream. Harvest was conducted using high lead cable yarding. Yarding across the stream and through the RMZ occurred in two places. Trees cut on approximately 1 hectare on the west side of the stream were yarded to the east side using cable systems. RMZ width averaged 7 meters in the vicinity of the survey area. The harvest was completed in March 1993.

The BMPs evaluated at this site are the RMZ along the Type 3 stream with adjacent cable harvesting and yarding across the stream. Two study reaches were established on Type 3 stream. The treatment reach is along the lower portion of the RMZ, and the control reach is located upstream of the harvest unit boundary. The control reach has a cascade morphology, with an average active channel width of 7 meters and an average channel gradient of 13%. Both study reaches were evaluated using channel condition surveys in March 1993 and August 1994. Stream amphibian surveys were conducted within the treatment reach as part of a University of Washington research project. Sediment routing surveys were conducted at the site in August 1993 and August 1994.

Site S-04
Friday Creek II



Harvest BMP Effectiveness Summary

Study Site:	S-04: Friday Creek II - Clearcut harvest with RMZ						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01		Not Effective				
Case Narrative:	Soil disturbance produced by cable yarding practices at this site was 18% of the survey area for the first-year survey (5 months following harvest), and 12% for the second-year survey (17 months following harvest). Chronic sediment delivery to the stream buffered by an RMZ was primarily associated with cable yarding routes that crossed the stream and RMZ, which accounted for 72% of the exposed soil associated with erosion features that delivered sediment. Another 26% of the exposed soil from erosion features that delivered sediment was attributed to stream bank erosion not associated with harvest activities, and minor amounts of sediment delivery were attributed to erosion from windthrow and wildlife activities. The RMZ prevented sediment delivery to the type 3 stream where it was not crossed by yarding routes.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01/CS-02		Effective				
Case Narrative:	Channel condition survey results do not show in-stream impacts associated with the timber harvest activities evaluated. A decrease in channel condition scores was observed in both treatment and control reaches, primarily associated with increased streambed mobility. Although chronic sediment delivery was documented in the sediment routing surveys, the high gradient study reach has a relatively low potential to store fine sediment.						
	OVERALL SITE BMP EFFECTIVENESS RATING:		PARTIALLY EFFECTIVE				

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Friday Creek II	Survey Date	8/19/1993
Site Id #	S-04	Survey Id #	SR-01
Water Type	3	Months Since Harvest	5

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	yes	26.0	not recorded	n/a
2	yarding	yes	1029.0	not recorded	n/a
3	eroding left bank	yes	11.3	not recorded	n/a
	TOTALS	3 delivered	1066.3		

Total Area of Ground Surveyed = 0.6 hectares

Total Length of Stream Bank Surveyed = 344 meters

Disturbed Soil per Hectare = 1777.2 m^2/ha

Total Area Exposed Soil per Hectare = not determined

Total Disturbed Soil Area from All Erosion Features that Delivered to Water = 1066.3 m^2

Disturbed Soil from All Erosion Features that Delivered per Hectare = 1777.2 m^2/ha

*** Total Disturbed Soil Area from Harvest Erosion Features that Delivered to Water = 1055.0 m^2**

*** Disturbed Soil from Harvest Erosion Features that Delivered per Hectare = 1758.3 m^2/ha**

* Features that delivered to water but were not directly attributable to current harvest practices, as fluvial bank erosion, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of disturbed soil)
yarding	2	1055.0	1055.0	98.9
bank erosion	1	11.3	11.3	1.1

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvest using cable yarding in the vicinity of a type 3 stream bufferd with a RMZ. The two yarding features that delivered sediment to the type 3 stream occurred where trees were yarded across and through the stream. The RMZ was effective at preventing sediment delivery in other parts of the survey area. The bank erosion feature identified was not related to recent harvest activities. The degree of soil exposure for erosion features was not determined in this preliminary field survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Friday Creek II	Survey Date	8/8/94
Site Id #	S-04	Survey Id #	SR-01
Water Type	3	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m2)
1	yarding	yes	16.2	0-25	2.0
(Note: original feature 2 now features 7 and 8)					
2	bank erosion	yes	6.5	75-100	5.7
3	wildlife activity	yes	6.0	25-50	2.3
4	yarding	no	340.7	50-75	212.9
5	bank erosion	yes	29.4	75-100	25.7
6	yarding	yes	62.7	75-100	54.9
7	yarding	yes	113.4	25-50	42.5
8	yarding	yes	117.6	25-50	44.1
9	windthrow	yes	3.8	75-100	3.3
10	bank erosion	yes	22.4	75-100	19.6
	TOTALS	9 delivered	718.7		413.0

Total Area of Ground Surveyed = 0.6 hectares

Total Length of Stream Bank Surveyed = 344 meters

Disturbed Soil per Hectare = 1197.8 m^2/ha

Area Exposed Soil per Hectare = 688.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 200.1 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 333.5 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 143.5 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 239.2 m^2/ha**

* Features that delivered but are not directly attributable to current harvest activities, such as windthrow, wildlife activity, or fluvial bank erosion, are excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	5	356.4	143.5	71.7
bank erosion	3	51.0	51.0	25.5
wildlife activity	1	2.3	2.3	1.1
windthrow	1	3.3	3.3	1.7

NARRATIVE:

The forest practices evaluated at the Friday Creek II site were clearcut harvest using cable yarding in the vicinity of a type 3 stream buffered by a RMZ. The RMZ averaged 7 meters in width in the vicinity of the survey area. Trees harvested on the west side of the stream were yarded across the stream and RMZ to a landing on the east side. The yarding scars that were delivering sediment to the stream in 1993 were continuing to do so at the time of the 1994 survey (17 months following harvest). The large yarding erosion feature identified as feature 2 in the 1993 survey was identified as two more distinct erosion features in 1994 (features 7 and 8). Features 4 and 6 are two yarding scars that were not identified as distinct erosion features in the preliminary survey. Several new features not directly attributable to harvest activities were identified in 1994, including bank erosion, wildlife activity, and windthrow. The RMZ continued to be an effective buffer preventing sediment delivery from harvest site erosion except where crossed. However, a substantial amount of chronic sediment delivery occurred where cable yarding routes crossed the stream and RMZ.

BMP EFFECTIVENESS RATING:

RMZ(Cable Yarding): NOT EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Friday Creek II S-04

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut with Cable Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Preliminary Surveys*:	54	3/17/93	59	3/17/93
Post-Treatment Survey #1:	46	8/8/94	48	8/8/94
Change from Pre-Treatment Score:	-8		-11	
Net Change (Control-Treatment):	+3			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
Both control and treatment reaches had decreases in channel condition scores over the monitoring period. Changes observed in both study reaches included increases bank erosion, increases in fresh sediment deposits, and increased streambed mobility, including destabilization of sediment storage elements. Because the control reach score decreased by a greater amount, there were no apparent effects of timber harvest activities within the RMZ stream reach.

(* Note: Timing of the initial surveys was concurrent with the harvest activities at the site. It was noted at the time of these surveys that no immediate in-stream impacts from logging were apparent in the treatment reach.)

Site S-05: Sundog

The Sundog site is located in north-central Pierce County in the Southern Cascades physiographic region. Harvest practices were evaluated at this site. The surface geology of the site is classified as alpine glacial deposits and mudflows of the Ohanopecosh Formation. Soils in the vicinity of survey areas are mapped as Larrupin gravelly sandy loam, 30-65% slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutbank/fill/sidecast hazard and a medium erosion potential. The harvest BMP slope hazard category for the site is high, with stream valley hillslope gradients ranging from 36-70%.

The study stream at Sundog is a 1st order, Type 4 stream which was buffered with a RLTA. The stream is a tributary to the Carbon River. The average stream gradient is 28%. There is a Type 5 tributary entering the study stream in the upper portion of the unit.

Forest practices conducted at this site include a 46.5 hectare "new forestry" cut, with RLTAs left along all streams within the unit, and areas between the RLTAs clearcut. Width of the RLTA averaged 25 meters in the survey area along the Type 4 stream. About half of the harvest unit was yarded with cable systems, and the remaining area was shovel-logged. Total volume removal of trees was estimated at 85 percent. The harvesting was completed in June of 1993.

BMPs evaluated at the Sundog site were the RLTA along the Type 4 stream with adjacent cable harvesting. Sediment routing surveys were conducted along the stream and RLTA in the area between the upper road and the lower road in October 1993 and October 1994. Stream amphibian surveys were conducted on the same study stream as part of a University of Washington research project.


Site S-05
Sun Dog
Roads
Streams
Harvest Unit
RLTA
10 Meter Contour
Washington
50 0 50 100 Meters
660
640
600
580
560
540
520
500
480
T4
T5
SR-01

Harvest BMP Effectiveness Summary

Study Site:	S-05: Sundog - Clearcut harvest with RLTA						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding
		WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01						Effective
Case Narrative:	The RLTA was effective at preventing direct sediment delivery to the type 4 stream. Timber was yarded away from the stream on both sides of the RLTA, and there was no yarding across the stream or buffer within the survey area. Sediment delivery documented in the sediment routing surveys was primarily associated with erosion from windthrow, with minor amounts from two erosion features that were attributed to residual yarding scars associated with the logging of the original forest.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Separate in-stream surveys were not conducted.						
Case Narrative:	No direct in-stream effects of timber harvesting were observed during sediment routing surveys.						
	OVERALL SITE BMP EFFECTIVENESS RATING:						EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sundog	Survey Date	10/5/93
Site Id #	S-05	Survey Id #	SR-01
Water Type	4	Months Since Harvest	4

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	no	4.0	not recorded	n/a
2	unknown	yes	72.0	not recorded	n/a
3	windthrow cluster	yes	143.0*	not recorded	n/a
4	windthrow cluster	yes	141.0*	not recorded	n/a
	TOTALS	3 delivered	360.0		

* Note: for the features identified as windthrow clusters, the area of the zone of disturbance is given rather than the surface area of individual windthrow erosion features.

Total Area of Ground Surveyed = 3.1 hectares

Total Length of Stream Bank Surveyed = 856

Disturbed Soil per hectare = 116.1 m^2/hectare

Total Area Exposed Soil per Hectare = not determined

Total Disturbed Soil Area from All Erosion Features that Delivered to Water = 360.0 m^2

Disturbed Soil from All Erosion Features that Delivered per Hectare = 114.8 m^2/ha

*** Total Disturbed Soil Area from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Disturbed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* Features that delivered to water but were not directly attributable to current harvest practices, as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Disturbed Soil (m^2)	Disturbed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of disturbed soil)
unknown cause	1	72.0	72.0	20.2
windthrow	3	288.0	284.0	79.8

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using cable yarding methods on both sides of a type 4 stream buffered with a Riparian Leave Tree Area (RLTA). The trees harvested were yarded away from the RLTA on both sides of the stream in the vicinity of the survey area. This practice prevented direct sediment delivery to the buffered stream from harvest site erosion. Windthrow within the RLTA was associated with a minor amount of sediment delivery to the stream. The erosion feature (#2) attributed to unknown causes appeared to be residual gully erosion from a large yarding scar associated with logging of the original forest. The degree of soil exposure was not determined in this preliminary field survey.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sundog	Survey Date(s)	10/7/94
Site Id #	S-05	Survey Id #	SR-01
Water Type	5	Months Since Harvest	16

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	no	4.0	75-100	3.5
2	unknown	yes	30.0	25-50	11.3
3	windthrow cluster	yes	30.0	75-100	26.3
4 *	windthrow	no	4.1	50-75	2.6
5 *	windthrow	yes	2.9	25-50	1.1
6 *	windthrow	yes	8.0	50-75	5.0
7 *	windthrow	yes	5.2	50-75	3.3
8 *	windthrow	yes	5.1	25-50	2.0
9 *	windthrow	no	6.4	50-75	4.0
(* Feature 4 from the 1993 survey is a cluster of six windthrow features that were measured individually in 1994.)					
10	windthrow	no	5.7	75-100	5.0
11	windthrow	no	6.8	25-50	2.6
12	windthrow	yes	21.5	50-75	13.4
13	windthrow	yes	11.3	75-100	9.9
14	windthrow	no	6.4	75-100	5.6
15	windthrow	no	13.0	50-75	8.2
16	windthrow	no	6.7	75-100	5.9
17	windthrow	yes	2.3	50-75	1.4
18	windthrow	yes	1.3	50-75	0.8
19	windthrow	no	8.8	75-100	7.7
20	unknown	no	6.2	0-25	0.8
21	windthrow	no	2.3	75-100	2.0
22	windthrow	no	2.7	75-100	2.4
	TOTALS	10 delivered	190.7		124.8

Total Area of Ground Surveyed = 3.1 hectares

Total Length of Stream Bank Surveyed = 856 meters

Disturbed Soil per hectare = 61.5 m^2/hectare

Exposed Soil per hectare = 40.3 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 74.5 m^2.

Exposed Soil from All Erosion Features that Delivered per Hectare = 24.0 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2.**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/hectare**

* Features that delivered but were not directly attributable to current harvest activities, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
windthrow	20	112.7	63.2	84.8
unknown cause	2	12.1	11.3	15.2

NARRATIVE:

The forest practices evaluated with this survey were clearcut harvesting using cable yarding methods on both sides of a type 4 stream buffered with a Riparian Leave Tree Area (RLTA). Windthrow within the RLTA was the major cause of erosion associated with sediment delivery to the stream. Features 10-22 were not identified as distinct erosion features during the preliminary survey, and many of these may be windthrow that occurred between the 1993 and 1994 surveys. The erosion features attributed to unknown causes (features #2 and #20) appeared to be residual gully erosion from yarding scars associated with logging of the original forest. The average width of the RLTA was 25 meters in the vicinity of the survey area, which buffered the steep inner gorge along the stream. The trees harvested were yarded away from the RLTA on both sides of the stream in the vicinity of the survey area. This practice was effective in preventing direct sediment delivery to the buffered stream from harvest site erosion.

BMP EFFECTIVENESS RATING:

RLTA (Cable Yarding): EFFECTIVE

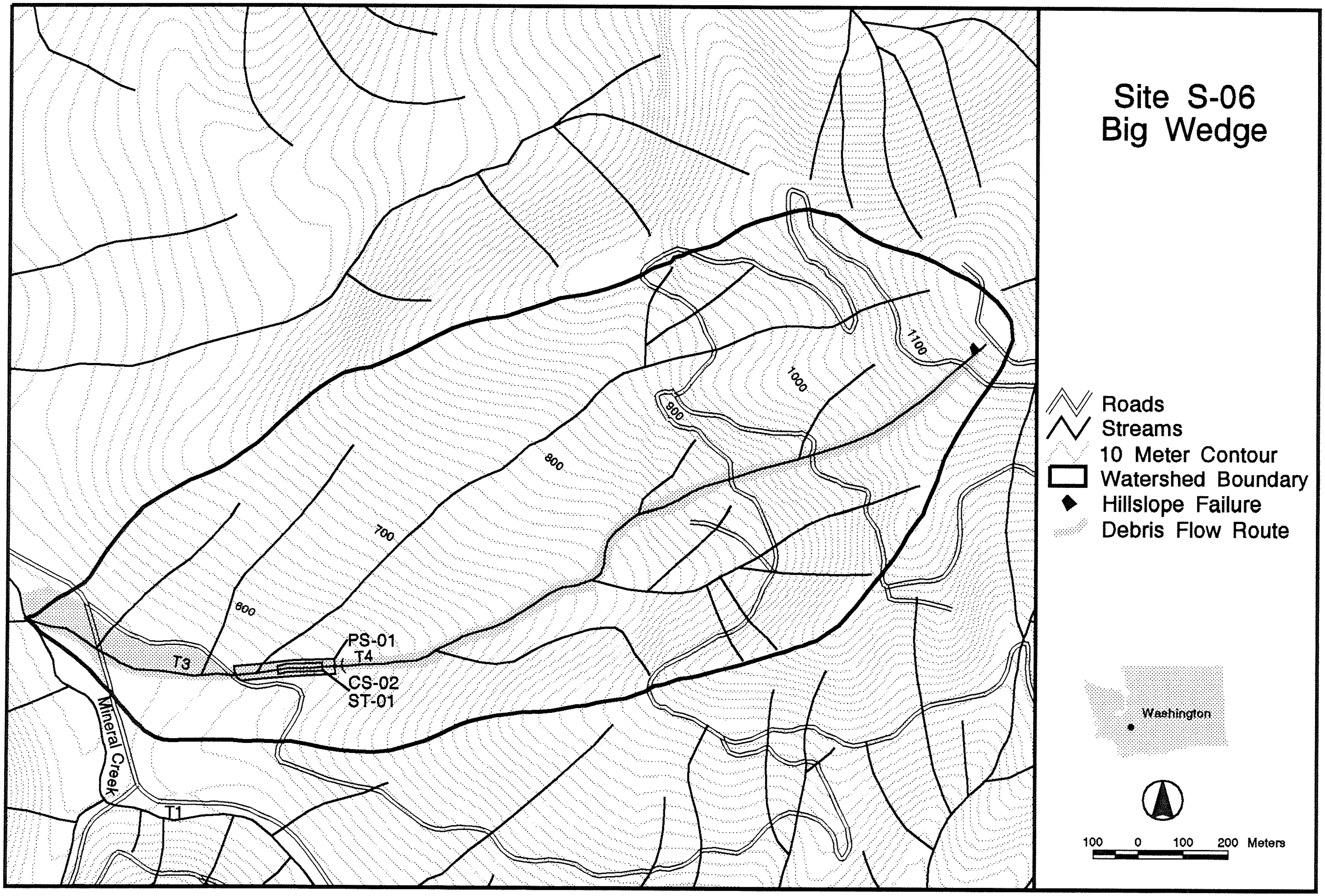
Site S-06: Big Wedge

The Big Wedge site is located in north-central Lewis County in the Southern Cascades physiographic region. Harvesting practices were targeted for evaluation at this site, but the harvest was postponed due to the occurrence of a debris flow event. The surface geology of the site is mapped as basaltic andesite and andesite flows. Soils at the study site are classified as Pheeney-Jonas complex, 8-30% slopes. The soils are rated as stable for disturbed slope stability, with a slight cutbank/fill/sidecast hazard and a medium erosion potential. Based on stream valley side slopes measured in the study reaches, the harvest BMP slope hazard category for the site is high (side slopes range from 19-55%).

The study stream at the Big Wedge site is a 1st order, Type 3 stream that is a tributary to Mineral Creek in the Nisqually River basin. Within the study reaches, this stream had a step-pool morphology prior to the debris flow, with an average channel gradient of 9%.

Forest practices targeted for evaluation at the Big Wedge site included a proposed 15 hectare clearcut, with ground-based harvesting adjacent to the Type 3 stream, which was to be buffered with a RMZ. However, the proposed harvest did not occur during the period of field monitoring for this study. The harvest was postponed due to the occurrence of a debris flow which ran through the study stream during a rain-on-snow event in December 1994. The debris flow was triggered by a small hillslope failure on a clearcut valley wall in the uppermost reaches of the stream, about 1,700 meters upstream of the study reaches in the proposed harvest area. Relief drainage from a road just upslope of the landslide may have been a contributing factor. The runout for the debris flow began just downstream of a road that bisected the proposed harvest area and continued to the confluence with Mineral Creek.

Four study reaches were established on the Type 3 stream to serve as treatment and control reaches within and immediately upstream of the proposed timber harvest unit. Preliminary surveys conducted during the summer of 1993 through the summer of 1994 included channel condition surveys on four reaches, and photo point and streambed stability surveys on three reaches. In the interests of documenting some of the physical stream channel effects of the debris flow, the results from before and after streambed stability surveys on one of the study reaches are reported in this case summary. These survey results characterize the changes in streambed complexity and in-channel sediment storage that occurred over the monitoring period. Other surveys originally intended to evaluate harvest practices were not used in the post-debris flow evaluation and are not reported.


Site S-06
Big Wedge
Roads
Streams
10 Meter Contour
Watershed Boundary
Hillslope Failure
Debris Flow Route
Washington
100 0 100 200 Meters
1100
1000
900
800
700
600
PS-01
T4
CS-02
ST-01
T3
T1
Mineral Creek

Site S-06: Big Wedge - Streambed Stability Survey Results

Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)	Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)
6/22/94	ST-01	1	1.2	7/20/95	ST-01	1	0.3
6/22/94	ST-01	2	0.8	7/20/95	ST-01	2	0.05
6/22/94	ST-01	3	2.2	7/20/95	ST-01	3	0.05
6/22/94	ST-01	4	0.3	7/20/95	ST-01	4	0.05
6/22/94	ST-01	5	4.9	7/20/95	ST-01	5	0.15
6/22/94	ST-01	6	3.2	7/20/95	ST-01	6	0.05
6/22/94	ST-01	7	4.2	7/20/95	ST-01	7	0.1
6/22/94	ST-01	8	2.9	7/20/95	ST-01	8	0.3
6/22/94	ST-01	9	0.8	7/20/95	ST-01	9	0.6
6/22/94	ST-01	10	2.4	7/20/95	ST-01	10	0.1
6/22/94	ST-01	11	0.1	7/20/95	ST-01	11	0.05
6/22/94	ST-01	12	2.1	7/20/95	ST-01	12	0.15
6/22/94	ST-01	13	0.9	7/20/95	ST-01	13	0.25
6/22/94	ST-01	14	4.1	7/20/95	ST-01	14	0.15
6/22/94	ST-01	15	0.7	7/20/95	ST-01	15	0.15
6/22/94	ST-01	16	4.4	7/20/95	ST-01	16	0.2
6/22/94	ST-01	17	3.7	7/20/95	ST-01	17	0.05
6/22/94	ST-01	18	26.4	7/20/95	ST-01	18	3.9
6/22/94	ST-01	19	0.4	7/20/95	ST-01	19	1.1
				7/20/95	ST-01	20	0.1
				7/20/95	ST-01	21	0.1
				7/20/95	ST-01	22	0.05
				7/20/95	ST-01	23	0.8
				7/20/95	ST-01	24	0.2
Total Volume Stored in Reach (m^3):			65.7				9.0
Average Volume of Sediment Deposits (m^3):			3.5				0.4
Reach Length (meters):			95				95
In-Channel Sediment Storage (m^3/100m):			69.2				9.5

Case Narrative:

These survey results reflect the changes in in-channel sediment storage that occurred in the study reach as a result of a debris flow that ran through the reach in December 1994. For approximately 1700 meters upstream of the study reach, the stream channel had been scoured to bedrock, but some amount of deposition of colluvial and alluvial materials had occurred within the study reach, where stream confinement and gradient lessened. The main runout for the debris flow was downstream of the study reach. Prior to the debris flow event, the reach had numerous distinct sediment wedges, all of which were formed in association with large woody debris pieces. These included both naturally occurring woody debris and cull logs from the logging of the original forest, and appeared to have been anchored in place for decades. Following the debris flow, none of the original sediment wedges or woody debris pieces were present. The zone of disturbance within the study reach encompassed four to six times the previous active channel width. At the time of the follow-up survey, about seven months following the event, numerous small sediment wedge features were observed. These were exclusively associated with cobble clusters (a few having small boulders), and did not appear stable so as to persist through normal winter flow regimes. The total volume of in-channel sediment storage within the reach decreased by 86% from before to after the debris flow event, and the average volume of the in-channel sediment deposits decreased from 3.5 cubic meters to 0.4 cubic meters. Before the debris flow the reach had a complex step-pool morphology, whereas after the event it had a steep, plane-bed morphology.

Site S-07: Eleven Creek 32

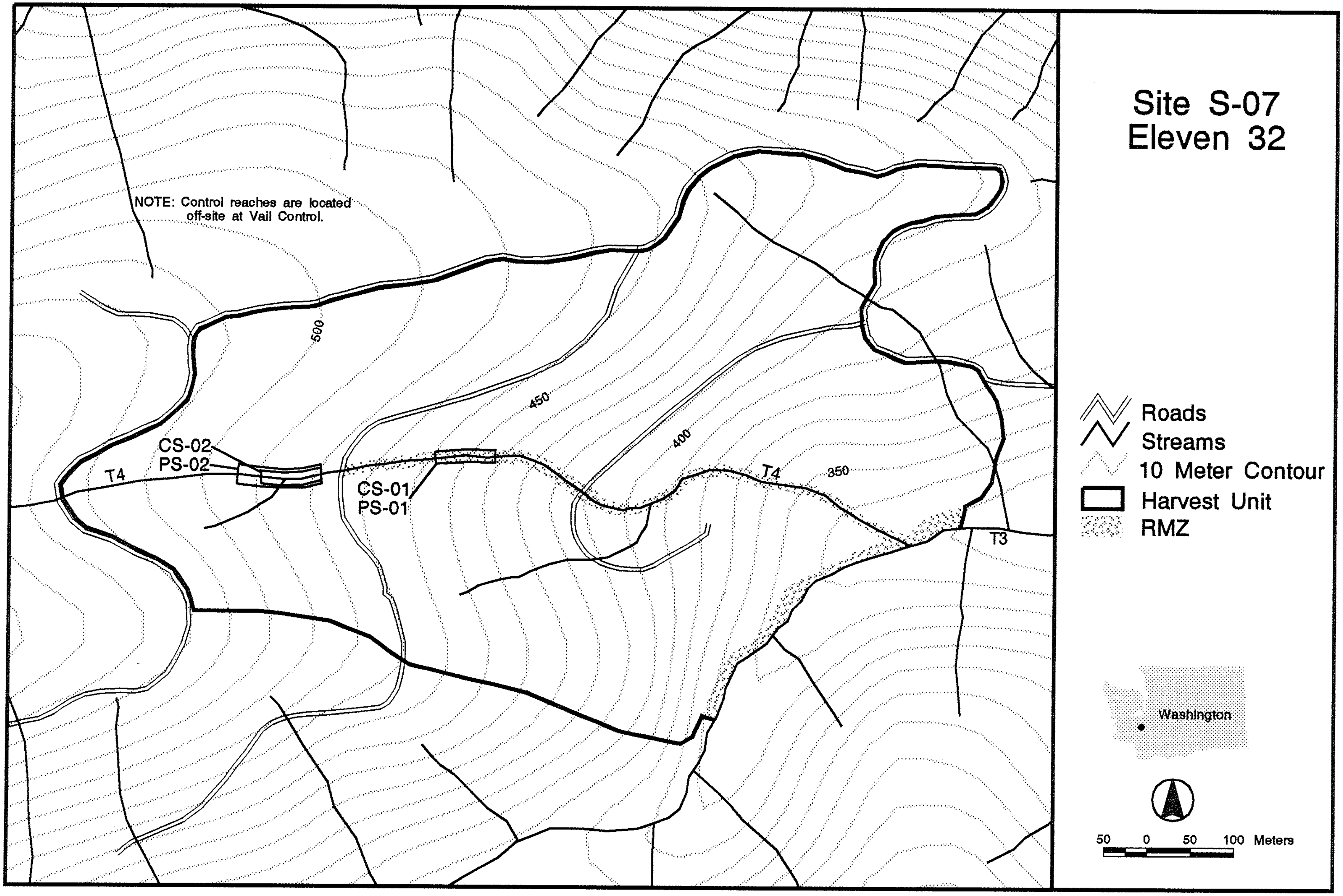
Eleven Creek 32 is a harvest practice evaluation site located in north-central Lewis County in the Southern Cascades physiographic region. This site is part of the CMER Wildlife-RMZ research project, and some of our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the area is classified as Eocene-aged basalt and andesite flows. Soils at the site are mapped as Baumgard loam, with 8-30% and 30-65% slope phases, and the Pheeney-Jonas complex, 8-30% slopes. These soils are rated as stable for disturbed slope stability, with a slight to moderate cutbank/fill/sidecast hazard, and a medium erosion potential. The harvest BMP slope hazard category for the site is high, based on stream valley side slopes exceeding 40% gradient in the vicinity of survey areas.

The study stream at this unit is a 1st order Type 4 stream that is a tributary to Eleven Creek, in the Skookumchuck River basin. The upper reaches of this stream within the harvest unit were classified as Type 5 on the DNR Water Type map and the FPA, however, it meets the physical criteria for a Type 4 water. The stream has a step-pool morphology, with an average active channel width of 1.5 meters and a gradient of 15% in the upper study reach. In a second, downstream study reach, the stream has a cascade morphology, with an average active channel width of 2.3 meters and a gradient of 26%.

Forest practices conducted at the Eleven Creek 32 site include a 41 hectare clearcut, using both ground-based (shovel) and cable yarding methods, with a RMZ established along the Type 4 stream for most of its length within the unit. (Although classified as a Type 4, the stream was buffered with a Type 3 regulation RMZ for the purposes of the CMER Wildlife-RMZ study.) The width of the RMZ averaged 8 meters in the vicinity of the survey area. The uppermost segment of the stream within the harvest unit was not buffered. The harvest was completed in July 1994.

Harvest BMPs evaluated at this site include the RMZ along the Type 4 stream with adjacent cable harvesting, and ground-based harvest along the upper portion of the same stream without stream buffers. Both study reaches were evaluated using channel condition and photo point surveys, with preliminary surveys conducted in February and March of 1994 and follow-up surveys conducted in May 1995. The two control stream reaches for these surveys are located at a nearby site referred to as Vail Control. Stream amphibian surveys were conducted within the RMZ reach, as well as at the Vail Control site, by investigators from the University of Washington as part of the CMER Wildlife-RMZ research project.

Site S-07
Eleven 32



Harvest BMP Effectiveness Summary

Study Site:	S-07: Eleven Creek 32 - Clearcut harvest with RMZ, and harvest without stream buffers						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	The RMZ was not yarded across in the vicinity of the survey areas; erosion features observed within the RMZ were associated with windthrow. Ground-based yarding across the type 4 stream occurred in the upper survey reach where the stream was not buffered.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01/CS-03		Effective				
	CS-02/CS-04			Not Effective			
	Photo Point:						
	PS-01/PS-03		Effective				
	PS-02/PS-04			Indeterminate			
Case Narrative:	The RMZ was effective at preventing direct impacts to the stream within the study reach. Stream channel changes observed over the monitoring period in the CS-01 survey (RMZ treatment reach) included increases in streambed mobility and a slight fining of the streambed. Both the CS-01 treatment and the CS-03 control reaches had some increased upper bank erosion. In the treatment reach this was associated with the extensive windthrow that occurred (the photo point survey documented 31 windthrown trees across the channel in a 61 meter reach). By contrast, surveys conducted to evaluate the upstream, un-buffered section of the same stream within the harvest unit showed substantial in-stream degradation associated with timber harvest activities. While the CS-04 control reach survey showed very little changes, the CS-02 treatment reach had a 53% decrease in the channel condition score over the monitoring period. Most of this degradation was associated with recent sediment deposition and a fining of the streambed, including a shift in the dominant particle size on the streambed surface from gravel to fines, and increased streambed mobility. Other adverse changes were associated with the extensive logging slash left in the channel, causing flow deflection onto stream banks. Although some increase in bank erosion was noted, it was also observed that the layer of logging slash appeared to have protected the stream banks from more extensive physical disturbance by ground-based yarding operations. The photo point survey comparison for the un-buffered reach is rated indeterminate because several of the rating elements could not be determined due to much of the channel being obscured by logging slash.						
	OVERALL SITE BMP EFFECTIVENESS RATING:		EFFECTIVE	NOT EFFECTIVE			

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Eleven 32 S-07

Treatment Survey ID#: CS-01 Water Type: 4
Control Survey ID#: CS-03 Water Type: 4

BMP(s) Evaluated: RMZ (Clearcut harvest using Cable-Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	45	2/3/94	56	3/15/94
Post-Treatment Survey #1:	40	5/16/95	54	5/10/95
Change from Pre-Treatment Score:	-5		-2	
Net Change (Control-Treatment):	-3			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:

Both treatment and control reaches are on relatively steep stretches of streams, with cascade morphologies and average gradients of 26% and 27%, respectively. The control reach is on a different type 4 stream located at the Vail Control study site. Despite the steep gradients, both reaches were storing fine sediments, behind obstructions and on sediment wedges, as well as in pools at the treatment reach. In fact, fines were the dominant particle size in the treatment reach during both surveys, though gravels were a close second and it was noted that the substrate was very diverse, with all size classes except large boulders and bedrock being represented. Both reaches had newly constructed or reconstructed roads crossing above them within about 100 meters, and these are likely sources of some of the fine sediment observed. In addition, there was an ongoing cedar salvage operation above the treatment reach at the time of the 1994 survey, and an old railroad grade was located upstream of the control reach, just below the previously mentioned logging road. During both preliminary and post-treatment surveys it was noted that there were old growth cull logs within, across, and adjacent to the channel on both streams, some oriented longitudinally, indicating that the streams were used as logging corridors during the logging of the original forest. Channel changes noted during the study period included increased upper bank erosion in both treatment and control reaches, with extensive windthrow disturbance noted in the treatment reach, some of it a source of fine sediment. Additional decreases in treatment reach score were attributable to destabilization of some sediment storage elements associated with small woody debris and slight increases bed mobility and the extent of non-pool surface fines.

In-Stream Photo-Point Survey Comparison Summary

Site: Eleven 32 Survey Years: 2/3/94 & 5/16/95

Study Reach Descriptions: 61 m. treatment reach on type 4 stream w/ RMZ; control reach is 49 m. on type 4 stream at Vail Control

Indicators of in-channel changes		Control PS-03 Yes	Control PS-03 No	Treatment PS-01 Yes	Treatment PS-01 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?			X	X	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X			X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X			X
4. Is there evidence of increased deposition or storage of fine or coarse sediment?			X		X
5. Are there changes in woody debris?					
* 31 new windthrown trees down across the channel in treatment reach between 1994 and 1995 surveys.	Increase in large WD?		X	X*	
	Increase in small WD?		X	X	
	Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X		X	

Summary:

The increased streambed mobility noted in the control reach was of relatively minor magnitude. The greatest changes observed in the treatment reach were associated with the extensive windthrow that occurred within the RMZ during the first winter following timber harvest, some of which caused increased bank erosion. A reduction of mosses on the substrate associated with streambed scour was observed in both reaches.

BMP Effectiveness Rating: Effective

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Eleven 32 S-07

Treatment Survey ID#: CS-02 Water Type: 4
Control Survey ID#: CS-04 Water Type: 4

BMP(s) Evaluated: Clearcut harvest using Ground-based-Yarding with no buffer

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	57	2/7/94	55	3/15/94
Post-Treatment Survey #1:	27	5/16/95	56	5/10/95
Change from Pre-Treatment Score:	-30		+1	
Net Change (Control-Treatment):	-31			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:

Both the CS-02 treatment and CS-04 control reaches are on the same respective streams as the CS-01 and CS-03 study reaches, but on lower gradient stretches of those streams with step-pool morphologies, having average gradients of 15% and 11%, respectively. The CS-02 reach is upstream of the CS-01 reach and a newly constructed road, and about 200 meters downstream of an older road which runs along the top of the harvest unit. The CS-04 reach is located downstream of the CS-03 control reach at the Vail Control site. There was an ongoing cedar salvage operation in the area of the treatment reach at the time of the 1994 survey, which resulted in some disturbance of the stream channel with some in-channel cedar cull logs being salvaged and others left undisturbed. During preliminary surveys on both treatment and control streams it was noted that there were old growth cull logs within, across, and adjacent to the channel, some oriented longitudinally, and it was noted that the streams were in a state of recovery from the destabilizing effects of being used as logging corridors during the logging of the original forest. Channel changes noted during the study period occurred almost exclusively within the treatment reach, and included slightly increased bank erosion (although it was still not very extensive--<25% of reach length affected) and numerous areas where flow was diverted into banks by logging slash, substantial increases in fresh sediment deposits (where there had been little to none observed during the pre-treatment survey) and greatly increased streambed mobility/brightness, increased fines in pools (as compared to a decrease in pool fines in the control reach), increased fines in non-pool areas, a shift from gravels as the dominant particle size to fines as dominant, destabilization of sediment storage elements associated with small woody debris (while old, LWD elements remained stable), and a shift in the dominant size of woody debris from predominately large logging debris (i.e. cull logs) to predominantly small logging slash. It was observed that the slash left in the channel was resulting in the formation of a new layer of fine sediment and organic matter essentially burying the pre-existing gravel substrate. It was also noted that the low-profile stream banks had apparently been protected from direct physical disturbance during shovel operation and yarding by the extensive slash.

In-Stream Photo-Point Survey Comparison Summary

Site: Eleven 32

Survey Years: 2/3/94 & 5/16/95

Study Reach Descriptions: 103 m. treatment reach on unbuffered type 4 stream; control reach is 75 m. on type 4 stream at Vail Control

Indicators of in-channel changes	Control PS-04 Yes	Control PS-04 No	Treatment PS-02 Yes	Treatment PS-02 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?	X		X	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?	X		Indeterminate	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X		Indeterminate	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X	Indeterminate	
5. Are there changes in woody debris?				
Increase in large WD?		X		X
Increase in small WD?		X	X	
Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X	X	

Summary:

Changes in streambed and bank conditions were observed in both treatment and control reaches. The bank disturbance was greater in the treatment reach. The greatest changes observed in the treatment reach were associated with the extensive logging slash covering the channel. This made comparisons of year-to-year conditions at most photo points inadequate for several rating elements, leading to an "Indeterminate" call for this survey. A reduction of mosses on the substrate associated with streambed scour was observed in the treatment reach.

BMP Effectiveness Rating: Indeterminate

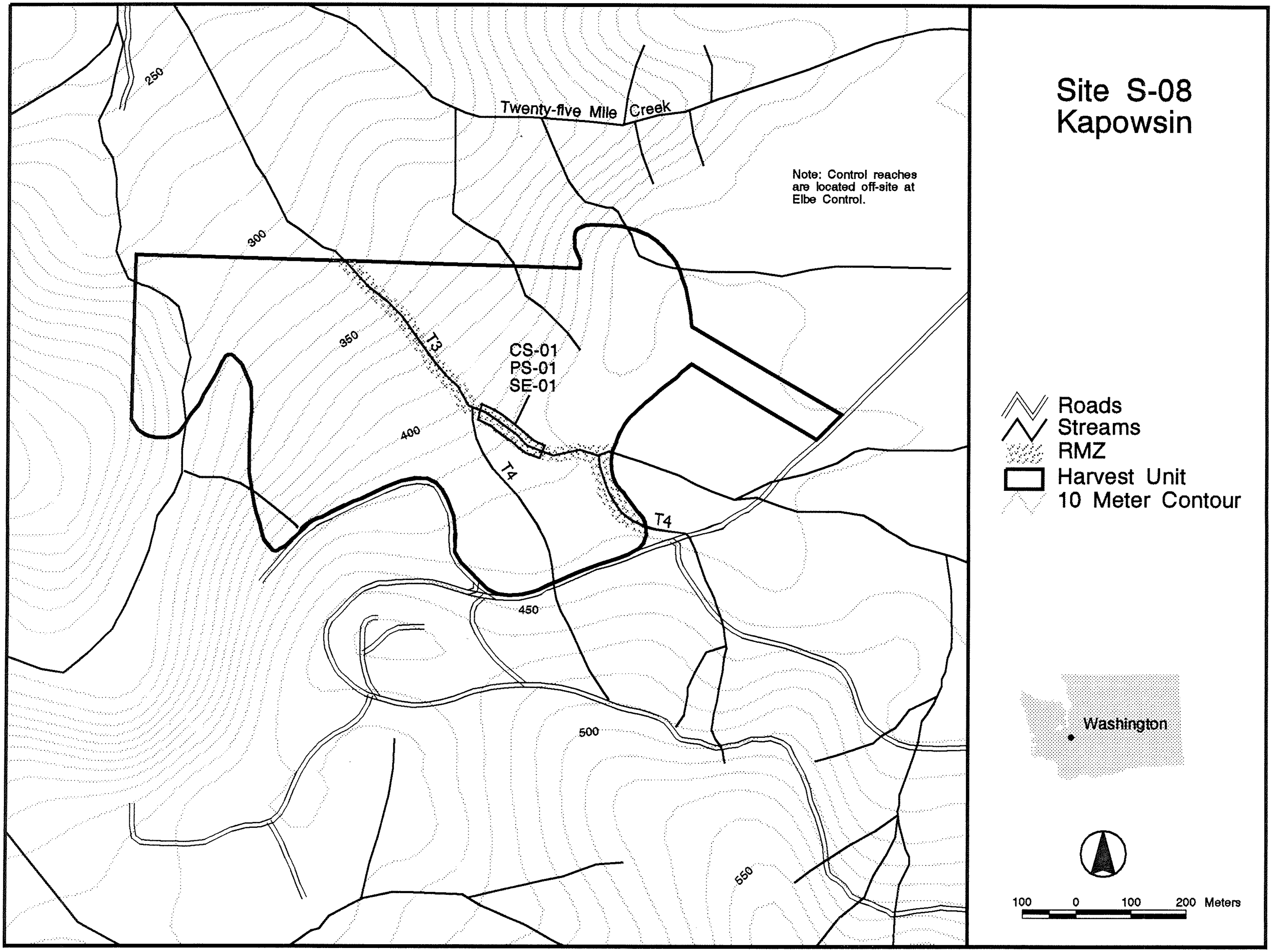
Site S-08: Kapowsin

The Kapowsin site is a harvest practice located in southeast Pierce County in the southern Cascades physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study 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 loam, 30-65% slopes, and Klaber-Cinebar complex, 0-3% slopes. The Wilkeson soil is rated as stable for disturbed slope stability, with a slight cutbank/fill/sidecast hazard and a medium erosion potential. The Klaber-Cinebar complex is rated as stable for disturbed slope stability, with a low erosion potential. The harvest BMP slope hazard category for the site is high, based on stream valley side slope gradients of 29-130% measured in the vicinity of study reaches.

The study stream at the Kapowsin site is a 2nd order, Type 3 tributary to Twenty-Five Mile Creek in the Nisqually River basin. Within the study reach, the stream has a step-pool morphology with an average active channel width of 5.4 meters and an average gradient of 11%, and runs through a steep inner gorge in sections.

Forest practices conducted at the Kapowsin site include a 46 hectare clearcut, with ground-based yarding (shovels) used in some areas and cable-yarding used in other portions of the unit. A RMZ was established on both sides of the Type 3 stream. The harvest, originally planned to occur in late 1993 or 1994, was delayed at this site and was not completed until March 1995.

Harvest BMPs evaluated at this site include the RMZ along the Type 3 stream with adjacent ground-based and cable harvesting. In-stream surveys conducted to evaluate BMP effectiveness include channel condition, photo point, and stream bank erosion surveys. The control stream for these surveys is located at another wildlife-RMZ study site in the same physiographic region, referred to as Elbe Control. Preliminary surveys at the treatment study reach were conducted in May 1993 and April 1994, with follow-up surveys conducted in May 1995. At the control reach, pre-treatment surveys were conducted in August and December of 1993 and May and July of 1994, with post-treatment surveys conducted in May 1995. Stream amphibian surveys were conducted within the RMZ reach, as well as at the Elbe Control site, by investigators from the University of Washington as part of the CMER Wildlife-RMZ research project.



Site S-08
Kapowsin
Note: Control reaches are located off-site at Elbe Control.
Twenty-five Mile Creek
CS-01
PS-01
SE-01
T3
T4
T4
250
300
350
400
450
500
550
Roads
Streams
RMZ
Harvest Unit
10 Meter Contour
Washington
100
0
100
200 Meters

Study Site:	S-08: Kapowsin - Clearcut harvest with RMZ						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	While no sediment routing or other hillslope erosion/delivery surveys were conducted to evaluate this harvest practice, it was noted in post-harvest stream surveys that minor amounts of sediment delivery were occurring, via ravel and runoff, due to valley wall disturbance associated with yarding activity within the RMZ. Although there was a minor amount of harvest and yarding activity within the RMZ, the stream and RMZ were not crossed within the survey areas. The main sediment source observed was windthrow within the RMZ and inner gorge.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01/CS-02	Effective	Effective				
	Photo Point: PS-01/PS-02	Partially Effective	Partially Effective				
	Stream Bank Erosion: SE-01/SE-02	Partially Effective	Partially Effective				
Case Narrative:	Channel changes were observed in both treatment and control reaches between pre-treatment and post-treatment surveys, but channel condition survey scores decreased by a greater amount in the control reach. Changes observed in the treatment reach included increased stream bank erosion, including upper bank disturbance, and destabilization of sediment storage elements within the channel. Photo point surveys documented the increased streambed mobility, including a reduction in aquatic plants in the treatment reach due to scour and bed mobility, as well as the windthrow that occurred (at least 17 new windthrown trees across the channel were observed over the 135 meter treatment reach). The stream bank erosion surveys found that yarding activity within the RMZ caused disturbance along one section of the valley wall, but the disturbed banks were also affected by windthrow and scour by high stream flows. The main causes of bank erosion in the post-harvest survey of the RMZ treatment reach were windthrow and scour by flowing water. The post-harvest monitoring period at this site was short (only 2-3 months) because the harvest was delayed and occurred at least one year later than originally planned.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	PARTIALLY EFFECTIVE	PARTIALLY EFFECTIVE				

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Kapowsin S-08

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut harvest, using both Cable & Ground-based-Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	64	5/27/93	65	8/10/93
2nd Pre-Treatment Survey @ Control Reach:			60	7/21/94
Post-Treatment Survey :	62	5/23/95	56	5/17/95
Change from Pre-Treatment Score:	-2		-9	
Net Change (Control-Treatment):	+7			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:

The CS-01 treatment and CS-02 control reaches are on different type 3 streams (the control reach is at the Elbe Control study site), both having step-pool morphology, and average gradients of 11%. The slight decrease in channel condition score for the treatment reach is attributed to increased upper bank disturbance and destabilization of sediment storage elements associated with woody debris. However, changes in channel conditions in the control reach were of greater magnitude over the monitoring period, and included increases in fresh sediment deposition, a fining of substrate in pools, and increased bed mobility. Changes between 1994 and 1995 at the control reach reflected the effects of one or more bed mobilizing peak flow events during the last winter of the study period. It was noted that a side channel in the control reach had experienced flow and was storing fresh sediment deposits. Likewise, the effects of peak flow events, such as increased streambed mobility were evident in the treatment reach. As observed at several other clearcut RMZ study sites in western Washington, a substantial reduction of mosses which had covered the larger substrate was noted within the treatment reach, and this is attributed to the increased streambed mobility and/or changes in the riparian canopy associated with timber harvest and windthrow.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey

Site: Kapowsin S-08 — Treatment
Survey Dates: 4/94 & 5/95 — Water Type: 3
Survey #: SE-01 — Total reach length center line: 130 m

Length of left bank: 147 m
Length of right bank: 137 m
Total Bank length: 284 m

	1993	1994	1995
Total # eroding banks		8	19
Total # Sampled		8	19
Total length of eroding banks		20.8m	88.9m
Total area of eroding banks		12.2 sq. m.	111.5 sq. m.
% of bank length eroding:		7.3%	31.3%

Cause of Bank Erosion:	Length of Eroding Banks:	
Flowing Water	20.8m	37.4m
Windthrow		42.0m
Yarding/scour/windthrow combination		9.5m

Stream Bank Erosion Survey

Site: Elbe Control — Control
Survey Dates: 12/93, 5/94 & 5/95 — Water Type 3
Survey #: SE-02 — Total reach length center line: 76 m

Length of left bank: 88 m
Length of right bank: 86 m
Total bank length: 174 m

	1993	1994	1995
Total # eroding banks	4	6	7
Total # Sampled	4	6	7
Total length of eroding banks	11.3m	12.5m	12.3m
Total area of eroding banks	3.7 sq. m.	3.8 sq. m.	4.3 sq. m.
% of bank length eroding	6.5%	7.2%	7.1%

Cause of Bank Erosion:	Length of Eroding Banks:		
Flowing Water	11.3M	12.5M	12.3M

Forest practices evaluated at the Kapowsin site are clearcut harvesting using both ground-based and cable-yarding equipment, with a two-sided RMZ along a type 3 stream. A few trees were cut from within the RMZ, but yarding activity within the buffer was observed in only one area which affected two of the eroding banks documented in the 1994 survey. The comparison of 1994 conditions to 1995 clearly shows an increase in bank erosion within the treatment reach due to scour from flowing water and especially due to windthrow following the 1994 harvest. At least 17 new windthrown RMZ trees associated with streambank erosion were documented in the 1995 survey. In addition, bank erosion associated with yarding disturbance of valley walls/upper banks and channelized runoff from the clearcut area which was routed across the valley wall of the steep inner gorge was documented in the treatment reach during the 1995 survey. The two banks affected by yarding activities, accounting for about 11% of the total eroding bank length and surface area and 3% of the total streambank length in the reach, were also affected by either windthrow or scour by high stream flows. These two banks were adjacent to each other; in all, a 10 meter section of the valley wall was affected by this yarding disturbance. Because the disturbance from timber harvest activities was isolated to this one area of the RMZ, the BMP is rated "Partially Effective" in this case. Windthrow is the biggest single source of bank erosion in the study reach. The amount of bank erosion within the control reach at the Elbe Control site remained stable over the monitoring period.

BMP Effectiveness Rating: PARTIALLY EFFECTIVE

In-Stream Photo-Point Survey Comparison Summary

Site: Kapowsin — Survey Years: 5/93 and 5/95 @ Kapowsin (8/93, 7/94, and 5/95 @ Elbe Control)

Study Reach Descriptions: 135 meter treatment reach in a type 3 stream. The control reach is a 68 meter reach at the Elbe Control site.

Indicators of in-channel changes		Control PS-02 Yes	Control PS-02 No	Treatment PS-01 Yes	Treatment PS-01 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks? *Primarily associated with windthrow.			X	X*	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?			X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)? * some cobbles and sm. boulders were mobilized and scoured of moss.			X	X*	
4. Is there evidence of increased deposition or storage of fine or coarse sediment?			X		X
5. Are there changes in woody debris? * At least 17 RMZ trees documented as windthrown across the channel between 1993 and 1995 @ Kapowsin. Only 1 new windthrow crossing the stream was documented @ the Elbe Control reach.	Increase in large WD?	X		X*	
	Increase in small WD?	X		X	
	Decrease in WD?	X			X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances? *Obvious loss of mosses within the active channel, due to scour and bed mobility, and/or riparian canopy changes.			X	X*	

Summary:

The most substantial changes observed within the treatment reach was the extensive windthrow which occurred. The photo-point survey at Kapowsin documents at least 17 new windthrown trees within or across the channel in the 1995 survey. Many of these windthrown trees were associated with bank erosion. Movement and scour of the substrate was also evident in some areas (e.g. photo points P1-P2 and P3-P4). There was a substantial reduction in mosses within the active channel. This is attributed to bed mobility and scour and /or changes in microclimate within the riparian zone associated with windthrow opening up the riparian canopy. Changes in woody debris documented in the control reach refers to the temporary formation of a small woody debris jam associated with an alder deadfall between the 1993 and 1994 surveys, which was removed by high flows between the 1994 and 1995 surveys. The survey in the RMZ treatment reach did not document any direct channel disturbance associated with tree falling or yarding practices, but the magnitude of change reflects decreased stream channel stability and increased streambed mobility, with effects on aquatic plants, resulting in a rating of "Partially Effective".

BMP Effectiveness Rating: Partially Effective

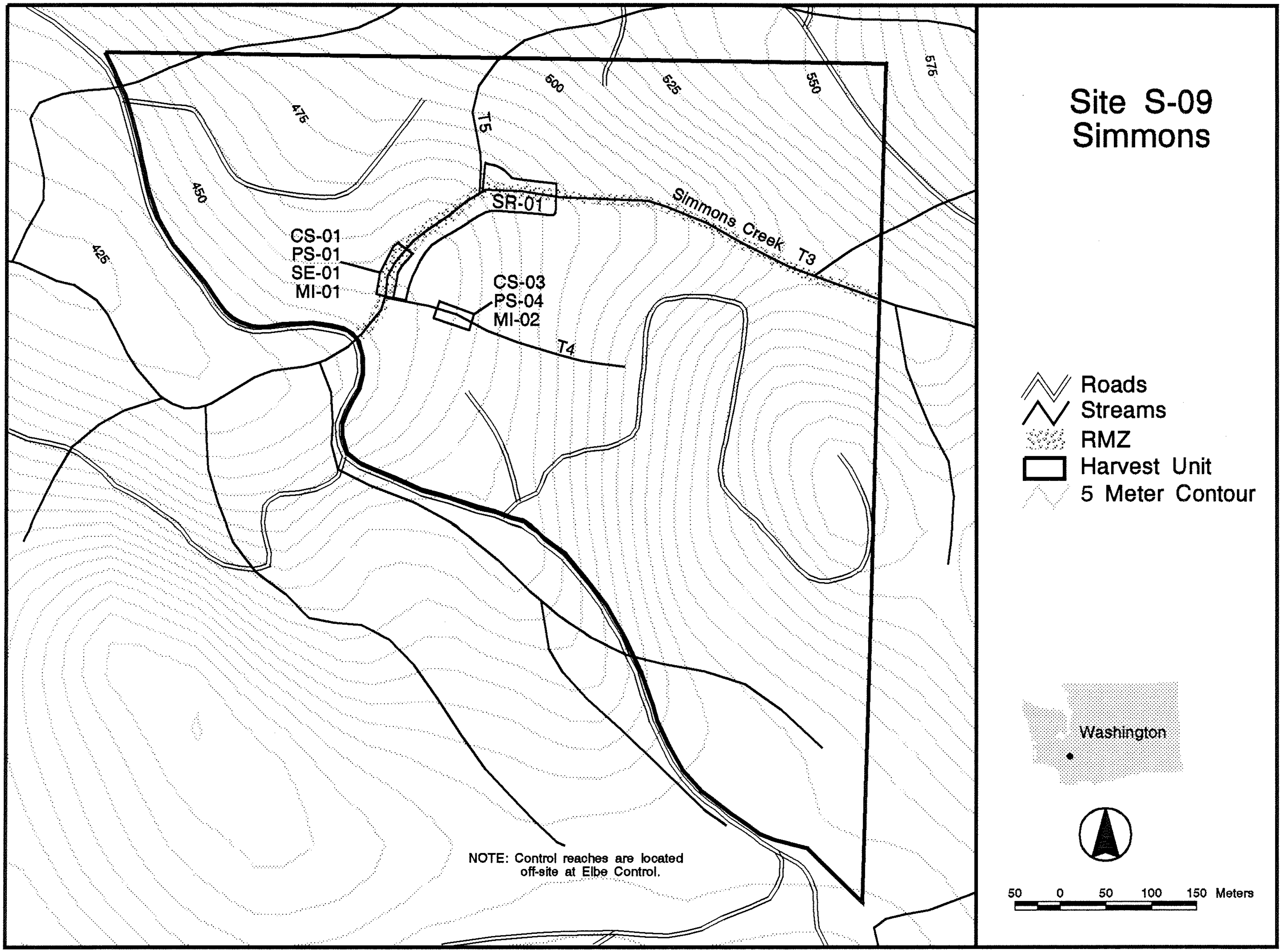
Site S-09: Simmons Creek

The Simmons Creek site is harvest practice located in south-central Lewis County in the Southern Cascades physiographic region. This site is part of the CMER Wildlife-RMZ research project, and some of our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the area is classified as Eocene and Oligocene-aged andesite and basalt flows. Soils at the site are mapped as Newaukum gravelly silt loam, 15-30% and 30-65% slopes. These soils are rated as stable for disturbed slope stability, with a slight to moderate cutbank/fill/sidecast hazard and a medium erosion potential. Based on stream valley side slopes of 25-45% measured in the vicinity of our study reaches, the harvest BMP slope hazard category for the site is high.

The study streams at this site include Simmons Creek, a 1st order, Type 3 stream, and a zero order Type 4 tributary to Simmons Creek. The Type 4 stream was mis-classified as a Type 5 on the FPA. Simmons Creek is a tributary to the Cowlitz River. The study reach on Simmons Creek has a step-pool morphology with an average active channel width of 3.9 meters and an average gradient of 8%. The study reach on the Type 4 stream has a step-pool morphology with an average active channel width of 1.5 meters and an average gradient of 12%.

Forest practices conducted at this site include a 49 hectare clearcut, with both ground-based (shovels) and cable yarding methods. A RMZ was established on both sides of the Type 3 stream. The width of the RMZ averaged 8 meters in the vicinity of survey areas. The harvest was completed in March 1994.

Harvest BMPs evaluated at this site include the RMZ along Simmons Creek with adjacent cable harvesting, and ground-based harvest practices along the Type 4 stream without stream buffers. Both study reaches were evaluated using channel condition and photo point surveys, with preliminary surveys conducted in May and September of 1993, and post-treatment surveys conducted in July 1994 and May 1995. The study reach on Simmons Creek was also evaluated using stream bank erosion surveys, with a preliminary survey conducted in September 1993, and post-treatment surveys conducted in May 1994 and May 1995. Macroinvertebrate sampling surveys were conducted on both Simmons Creek and the Type 4 tributary in late September of 1993 and early October of 1994 and 1995. The two control stream reaches for these in-stream surveys are located at the Elbe Control study site in the same physiographic region. At the control site, pre-treatment surveys were conducted in August and December of 1993, with post-treatment surveys conducted in May and July of 1994 and May 1995. Sediment routing surveys were conducted along a portion of the Simmons Creek RMZ in October 1994 and October 1995. Stream amphibian surveys were conducted within the RMZ reach, as well as at the Elbe Control site, by investigators from the University of Washington as part of the CMER Wildlife-RMZ research project.



Site S-09
Simmons
Roads
Streams
RMZ
Harvest Unit
5 Meter Contour
Washington
50 0 50 100 150 Meters
575
550
525
500
475
450
425
T5
SR-01
Simmons Creek T3
CS-01
PS-01
SE-01
MI-01
CS-03
PS-04
MI-02
T4
NOTE: Control reaches are located off-site at Elbe Control.

Harvest BMP Effectiveness Summary

Study Site:	S-09: Simmons Creek - Clearcut harvest, with RMZ and harvest without stream buffers						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01		Effective				
Case Narrative:	The sediment routing survey evaluated sediment delivery from cable yarding in the vicinity of a reach of Simmons Creek buffered by a RMZ. In the first-year survey (7 months following harvest), one yarding feature accounted for just over half of the erosion associated with sediment delivery to the creek, with the remainder attributed to two windthrow features. By the second-year survey conducted 19 months following harvest, the yarding erosion feature had re-vegetated, and the same two windthrow features were continuing to deliver minor amounts of sediment. The RMZ was effective at preventing chronic sediment delivery directly to Simmons Creek from harvest erosion features, although un-buffered tributaries were noted as sources of sediment.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01/CS-02		Partially Effective				
	CS-03/CS-04			Not Effective			
	Photo Point:						
	PS-01/PS-02		Partially Effective				
	PS-04/PS-03			Not Effective			
	Stream Bank Erosion:						
	SE-01/SE-02		Effective				
	Macroinvertebrate:						
	MI-01		Partially Effective				
	MI-02			Effective			
Case Narrative:	Channel condition surveys in the RMZ treatment reach showed a slight increase in bank erosion along straight stretches of the channel, increases in fresh sediment deposits and fines in pools, increased streambed mobility and destabilization of sediment storage elements associated with small woody debris, and a shift in the dominant type of woody debris in the channel. Some recovery in channel conditions within the treatment reach was observed between the first and second post-harvest surveys. Photo point surveys documented the increased streambed mobility, including a reduction in aquatic plants in the RMZ treatment reach associated with scour and bed mobility, as well as riparian canopy changes (17 new windthrown trees across the channel were observed over the 67 meter treatment reach). Stream bank erosion surveys reflected some increased bank erosion within the RMZ reach caused by windthrow, scour by high stream flows, and wildlife activity, but no direct bank disturbance by timber harvest activities. Channel surveys evaluating the un-buffered type 4 tributary documented in-stream degradation associated with timber harvest activities, including a substantial amount of sediment deposition and a fining of the streambed, resulting in a shift in the dominant particle size on the streambed surface from gravel to fines, increased streambed mobility and destabilization of sediment storage elements associated with small woody debris, and channel widening associated with the extensive slash and sediment accumulations. The low profile stream banks were apparently protected from direct physical disturbance during ground-based yarding operations by a layer of logging slash and old growth cull logs that had been left in place. Biological sampling showed temporary effects on the macroinvertebrate community in Simmons Creek as compared to the control stream, but no significant effects in the type 4 stream over the first two years following harvest.						
	OVERALL SITE BMP EFFECTIVENESS RATING:		PARTIALLY EFFECTIVE	PARTIALLY EFFECTIVE			

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Simmons Cr.	Survey Date	10/20/94
Site Id #	S-09	Survey Id #	SR-01
Water Type	3	Months Since Harvest	7

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACEAREA EXPOSED SOIL (m^2)
1	windthrow	yes	4.3	75-100	3.8
2	windthrow	no	14.0	75-100	12.3
3	yarding	no	5.9	25-50	2.2
4	old windthrow	no	5.1	0-25	0.6
5	windthrow	no	3.3	25-50	1.2
6	windthrow	no	7.4	25-50	2.8
7	yarding	no	9.1	75-100	8.0
8	windthrow	no	2.5	25-50	1.0
9	yarding	no	6.9	50-75	4.4
10	windthrow	no	4.8	25-50	1.8
11	yarding	no	8.0	50-75	5.0
12	windthrow	yes	12.9	75-100	11.4
13	falling/yarding	no	3.9	0-25	0.5
14	windthrow	no	12.4	75-100	10.9
15	yarding	no	20.8	25-50	7.8
16	falling/yarding	no	4.2	50-75	2.7
17	yarding	no	7.1	25-50	2.7
18	yarding	yes	18.4	75-100	16.1
19	yarding	no	43.0	50-75	26.9
20	yarding	no	6.8	25-50	2.6
21	yarding	no	5.3	25-50	2.0
22	yarding	no	8.0	50-75	5.0
23	yarding	no	2.5	75-100	2.2
24	yarding	no	7.8	75-100	6.8
25	falling/yarding	no	7.5	25-50	2.9
26	yarding	no	14.1	75-100	12.4
27	windthrow	no	9.5	50-75	6.0
	TOTALS	3 delivered	255.5		162.0

Total Area of Ground Surveyed = 1.0 hectares

Total Length of Streambank Surveyed = 377 meters

Disturbed Soil per Hectare = 255.5 m^2/hectare

Exposed Soil per Hectare = 162.0 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 31.3 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 31.3 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 16.1 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 16.1 m^2/hectare**

*Features that delivered but were not directly attributable to current harvest activities, such as windthrow, wildlife activity, etc., were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Windthrow	10	51.8	15.2	48.6
Yarding	14	104.1	16.1	51.4
Falling/Yarding	3	6.1	0.0	0

NARRATIVE:

The forest practices evaluated with this survey were include clearcut harvesting using cable yarding in the vicinity of a type 3 stream (Simmons Creek) buffered with a RMZ. The RMZ, which averaged 8 meters in width in the vicinity of the survey area and was not yarded across, was effective at preventing direct sediment delivery to Simmons Creek from erosion caused by timber falling and yarding activities, with the exception of erosion feature (#18) where yarding activities occurred within 10 meters of the stream. At least one of the several windthrow erosion features identified was associated with additional erosion from a cable yarding scar, and the tree itself was cable-damaged and may have been knocked down during logging.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Simmons Cr.	Survey Date	10/11/95
Site Id #	S-09	Survey Id #	SR-01
Water Type	3	Months Since Harvest	19

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	windthrow	yes	4.3	75-100	3.8
1-95	windthrow	no	3.8	50-75	2.4
2	windthrow	no	14.0	50-75	8.8
3	yarding	no longer eroding - revegetated			
2-95	windthrow	no	6.3	75-100	5.5
4	old windthrow	no longer eroding - revegetated			
5	windthrow	no	2.2	50-75	1.4
6	windthrow	no	1.9	50-75	1.2
3-95	windthrow	no	5.8	50-75	3.6
7	yarding	no longer eroding - revegetated			
8	windthrow	no longer eroding - revegetated			
9	yarding	no	3.8	25-50	1.4
10	windthrow	no longer eroding - revegetated			
11	yarding	no	8.0	0-25	1.0
12	windthrow	yes	13.0	75-100	11.4
13	falling/yarding	no longer eroding - revegetated			
14	windthrow	no	12.4	50-75	7.8
15	yarding	no	20.8	0-25	2.6
16	falling/yarding	no longer eroding - revegetated			
17	yarding	no longer eroding - revegetated			
18	yarding	no longer eroding - revegetated			
4-95	windthrow	no	6.0	75-100	5.3
5-95	yarding	no	100.0	0-25	12.5
(Features 19-27 from the 1994 survey were not re-surveyed in 1995)					
	TOTALS	2 delivered	202.3		68.7

Total Area of Ground Surveyed = 0.6 hectares

Total Length of Stream Bank Surveyed = 244 meters

Disturbed Soil per hectare = 337.2 m^2/hectare

Exposed Soil per hectare = 114.5 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 15.2 m^2.

Exposed Soil from All Erosion Features that Delivered per hectare = 25.3 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2.**

*** Exposed Soil from Harvest Erosion Features that Delivered per hectare = 0.0 m^2/hectare**

*Features not directly attributable to BMP implementation such as windthrow, wildlife activity, etc., which may have delivered to surface waters were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	4	17.5	0.0	0
windthrow	10	51.2	15.2	100

NARRATIVE:

The forest practices evaluated with this survey were include clearcut harvesting using cable yarding in the vicinity of a type 3 stream (Simmons Creek) buffered with a RMZ. The harvest area on the north side of the RMZ was not resurveyed in 1995, which accounts for the reduced survey area. Features 19-27 from the 1994 survey of the north side harvest area were all yarding-related erosion features, none of which delivered to surface waters; these features were not re-surveyed in 1995. Nine of the erosion features from 1994 were no longer eroding in 1995 due to natural revegetation. Six of these 9 features were yarding-related (including one that was associated with short-term sediment to Simmons Creek), and the other 3 were windthrow. Five new erosion features were identified in the 1995 survey, including four new windthrow features and one yarding-related erosion feature that was not mapped in 1994. The RMZ, which averaged 8 meters in width in the vicinity of the survey area and was not yarded across, was effective at preventing direct chronic sediment delivery to Simmons Creek from harvest site erosion.

BMP EFFECTIVENESS RATING:

RMZ (Cable Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Simmons Creek S-09

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Clearcut harvest using Cable-Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	63	5/27/93	65	8/10/93
Post-Treatment Survey #1:	47	7/19/94	60	7/21/94
Change from Pre-Treatment Score:	-16		-5	
Net Change (Control-Treatment):	-11			
Post-Treatment Survey #2:	50	5/24/95	56	5/17/95
Change from Pre-Treatment Score:	-13		-9	
Net Change (Control-Treatment):	-4			

BMP EFFECTIVENESS CALL: PARTIALLY EFFECTIVE

Case Narrative:

The CS-01 treatment and CS-02 control reaches are on different type 3 streams (the control reach is at the Elbe Control study site), with step-pool morphologies, and average gradients of 8% and 11%, respectively. The net decrease in channel condition score for the treatment reach was much greater during the first year following timber harvest, exceeding 10 points. Because the final scores reflect some recovery of channel conditions within the treatment reach, relative to the control, the BMP is rated "Partially Effective" in this case. Changes between 1994 and 1995 at the control reach reflected the effects of one or more bed mobilizing peak flow events during the last winter of the study period. It was noted that a side channel in the control reach had experienced flow and was storing fresh sediment deposits. Likewise, the effects of peak flow events were evident in the treatment reach, including the break-down of a small woody debris jam that had spanned the channel during the 1994 survey (but was not present in 1993) and obvious scouring of a windthrow rootwad. The decrease in channel condition scores for the treatment reach reflects the following changes noted during the study period: slight increases in bank erosion within straight stretches of the channel, increases in fresh sediment deposits and streambed mobility/brightness (similar changes also observed in the control reach during the second year), increased fines in pools (recovered by second year), destabilization of sediment storage elements associated with small woody debris (while elements associated with cobble/small boulder clusters remained stable), and a shift in the dominant size of woody debris to predominantly small logging slash. A substantial reduction of mosses which had covered the larger substrate was noted within the treatment reach in 1994, and this is attributed to the increased streambed mobility and/or changes in the riparian canopy associated with timber harvest and windthrow. In 1995 it was noted that a filamentous algae was becoming established on cobbles in areas under the more open canopy (e.g. windthrown areas), as well as distinct algae staining on substrate throughout the reach.

Stream Bank Erosion Survey Summary

Site: Simmons S-09	Treatment (Clearcut with RMZ)			Site: Elbe Control	Control		
Survey dates: 9/93, 5/94, & 5/95	Water Type: 3			Survey Dates: 12/93,5/94, & 5/95	Water Type: 3		
Survey #: SE-01	Total reach length center line: 67m.			Survey #: SE-02	Total reach length center line: 76m.		
		Length of left bank: 70m.			Length of left bank: 88m.		
		Length of right bank: 75m			Length of right bank: 86m.		
		Total Bank length: 145m.			Total bank length:174m.		
	Year				Year		
	1993	1994	1995		1993	1994	1995
Total # eroding banks	0	4	4	Total # eroding banks	4	6	7
Total length of eroding banks	0	12.5m	11.5m	Total length of eroding banks	11.3m	12.5m	12.3m
Total area of eroding banks	0	17.1 sq.m.	15.8 sq.m.	Total area of eroding banks	3.7 sq.m.	3.8 sq.m.	4.3 sq.m.
% of bank length eroding:	0%	8.6%	7.90%	% of bank length eroding	6.5%	7.2%	7.10%
Cause of Bank Erosion:	Length of Eroding Banks:			Cause of Bank Erosion:	Length of Eroding Banks:		
Wildlife Trail	0	2.1m	1.4m	Flowing water	11.3m	12.5m	12.3m
Windthrow	0	8.5m	8.8m				
Flowing Water	0	1.9m	1.3m				

Forest practices being evaluated at this site are clearcut harvesting using primarily cable-yarding (possibly assisted by shovels), with a RMZ along a type 3 stream. As can be seen from the analysis, the primary cause of increased bank erosion in the treatment reach between the 1993 (before harvest) and 1994/1995 surveys (after harvest) is windthrow of trees which were left as part of the RMZ and were rooted in the banks. While no eroding banks were mapped/measured at Simmons Creek in 1993, the wildlife disturbance (which met the criteria for an eroding bank in 1994 and 1995) was noted in 1993, but it did not meet the minimum size criteria that year. Two of the eroding banks mapped in 1994 (one caused by windthrow and one associated with flowing water) were no longer considered to be eroding in 1995, while two new eroding banks were measured that year (one caused by a new windthrow and one scoured by flowing water). While it did increase bank erosion to about 6% of total bank length, some of the windthrow was also noted as storing sediment and forming side channel habitat within the reach. Bank erosion attributable to scour by flowing water was about 1% of the total banks length in the treatment reach following the harvest, compared to about 7% in the control reach.

BMP Effectiveness Rating: EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Simmons Creek S-09

Treatment Survey ID#: CS-03 Water Type: 4
Control Survey ID#: CS-04 Water Type: 4

BMP(s) Evaluated: Clearcut harvest using Ground-based-Yarding with no buffer

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	62	9/13/93	56	12/29/93
Post-Treatment Survey #1:	23	7/14/94	52	7/21/94
Change from Pre-Treatment Score:	-39		-4	
Net Change (Control-Treatment):	-35			
Post-Treatment Survey #2:	30	5/24/95	45	5/17/95
Change from Pre-Treatment Score:	-32		-11	
Net Change (Control-Treatment):	-21			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:
The CS-03 treatment and CS-04 control reaches are on different type 4 streams (the control reach is at the Elbe Control study site), with step-pool morphologies, and average gradients of 12% and 16%, respectively. The CS-03 reach is a tributary to Simmons Creek, and the CS-04 reach is a tributary to the type 3 stream at Elbe Control. During preliminary surveys on both treatment and control streams it was noted that they appeared to have been used as yarding corridors during the logging of the original forest, and several large old growth cull logs were left along the treatment reach. The net decrease in channel condition score at the treatment reach reflects the following changes noted during the study period: some channel widening associated with slash and sediment/organic matter accumulation, substantial increases in fresh sediment deposits, where there had been little to none observed during the pre-treatment survey, and greatly increased streambed mobility/brightness (increased fresh sediment deposits were also observed in the control reach, but to a lesser degree), increased extent and depth of fines in pools, increased fines in non-pool areas, a shift from gravels as the dominant particle size to fines as dominant, destabilization of sediment storage elements associated with small woody debris (while some old, LWD elements remained stable), and a shift in the dominant size of woody debris from predominately large logging debris (i.e. cull logs) to predominantly small logging slash. It was observed that the slash left in the channel had resulted in the formation of a new layer of fine sediment and organic matter essentially burying the pre-existing gravel substrate. Most of these effects were more pronounced during the 1994 survey (first summer after logging). At the time of the 1995 survey, while some riffle areas were beginning to clean out revealing the previously existing gravel substrate in the thlaweg, channel margin areas, pools, and other riffles were still mostly fines and organic debris to a depth of 7-15 cm, including a spring which was flowing but heavily silted. Some filamentous algae was becoming established in sheltered areas by 1995. The low-profile stream banks had apparently been protected from direct physical disturbance during shovel operation and yarding by logging slash and old growth cull logs which were left in place.

Short-Term Observations on the Effects of Forest Clearing on Invertebrate Biota of a Cascade Range, Washington Stream

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Objectives of the Survey

The effects of forest clearing on stream biota was evaluated by measuring the response of the benthic macroinvertebrate assemblage. Biological surveys were conducted prior to the forest practice at a control (Elbe Site) and a treatment site (Simmons Creek). Three years of monitoring are incorporated in this analysis. Before-treatment surveys at both sites were completed in the late summer of 1993. Successive surveys were completed at the same sites during the same time period in 1994 and 1995.

The control site (Elbe) was used as a reference for the treatment site (Simmons). The focus for comparison was on: 1) significant changes in assemblage characteristics, and 2) the direction of change of an assemblage characteristic between years. Identifying the source of change (natural disturbance versus anthropogenic disturbance) was one approach used to isolate the effect of the forest practice on the biotic indicator.

Effects of Stream Disturbance on Biota

The effects on stream biota from changes in the chemical or physical environment have been measured at the individual, population and assemblage levels (a review by Johnson *et al.* 1993). This survey focused on the biological significance of potential changes in a stream environment: 1) following clearcut logging with a buffer (RMZ), and 2) following clearcutting an unbuffered first order stream.

Several measures are commonly used to identify changes in macroinvertebrate assemblages (Plafkin *et al.* 1989; Karr 1991; Resh and Jackson 1993). The measures, or biometrics, chosen for use in a survey depend on: 1) the type of land use expected to influence stream biota, and 2) the macroinvertebrate taxa present at a site. The direction of change for each biometric is based on the type of alteration that occurs at streamside or within the stream.

Canopy removal and timber yarding activities in and adjacent to the riparian zone can influence several instream variables. Water temperature, sediment transport to the stream, and periphyton growth can be directly affected. Each biometric indicates change when a specific component of the stream environment is altered (*e.g.*, physical, chemical or biological variables). Table 1 indicates the biometrics used in this survey and the expected changes should the clearcut with buffer treatment have degraded the macroinvertebrate assemblage.

Table 1. Expected benthic macroinvertebrate assemblage response to riparian alteration at Simmons Creek.

Assemblage Biometric	Expected Response
Total no. of taxa	decrease
Ephemeroptera,Plecoptera,Trichoptera taxa	decrease
% Scrapers	increase
% Shredders	decrease
% Predators	decrease
% Collector-filterers	increase
% Plecoptera	decrease
% Ephemeroptera	decrease
% Trichoptera	decrease
% Perlidae (stoneflies)	decrease
% Dominance (3 taxa)	increase

Expected direction of change for each biometric is based on explanations found in Plafkin *et al.* (1989), Resh and Jackson (1993) and Waters (1995).

Survey Design and Data Analysis

Biological surveys of benthic macroinvertebrate assemblages were completed before the clearcut at Simmons Creek (late September 1993) and after the clearcut (early October 1994 & 1995). Monitoring was conducted during the low flow period of each year. Water quality variables were measured along with several others that included the stream channel, riparian area and flow.

Four riffle samples were collected from the control site (Elbe) and four riffle samples were collected from the treatment site (Simmons). The Type 4 tributary was sampled with a lower level of intensity. Collection of biota was consistent for the survey period 1993 through 1995. Field methods are outlined in detail in Plotnikoff (1994).

Statistical analysis of the macroinvertebrate assemblage focused on inter-annual conditions at each site. Assemblage condition was compared between the 1993 and 1994 biological surveys at Elbe Site and the same comparison was made for Simmons Creek conditions. Other inter-annual comparisons made for each site were between 1994/1995 and 1993/1995. These inter-annual comparisons were made for each biometric and examined for significant differences. Results were compared to the possible assemblage responses listed in Table 1.

Biometrics were analyzed for significant inter-annual differences ($p \leq 0.05$) using the Student's t test. Transformation of the proportional data (i.e., % Scrapers) was done using the arcsine function. All other data (i.e., Total no. of taxa) was analyzed without the use of any transformation functions. Replicate samples collected from within a reach were expected to show low variation using community biometrics, but density estimates typically show higher variation.

Finally, specific taxa were identified that had responded to the forest-clearing treatment or other effects. Biological interpretation of any assemblage changes represented the finest level of detail in this analysis.

Results of Data Analysis & Interpretation

a) Pre-Harvest Conditions

The shaded stream corridor at Simmons Creek had a cool ambient temperature when the initial survey was done. Heavy growth of moss on streamside rocks and woody debris were also prominent. Light penetration to the stream was low (Table 2). The stream channel at Elbe Site was also heavily shaded by overhead canopy, but unlike Simmons Creek, it did not have dense streamside vegetation.

Several of the biotic assemblage characteristics were similar between the Elbe Site and Simmons Creek 1993 survey. Total no. of taxa, Ephemeroptera-Plecoptera-Trichoptera taxa, and % Dominance (3 taxa) all showed similar means and variation. Other biometrics were not substantially different for the control-treatment site comparison during pre-harvest conditions.

b) Post-Harvest Biological Conditions

Canopy cover appeared to be more dense at the Simmons Creek site during pre-harvest conditions. Canopy cover is denser in even-aged stands (Murphy and Meehan 1991) as appears to have been the case with this old second-growth stand at Simmons Creek. The effective canopy cover at the Simmons Creek reach declined in succeeding years. Table 2 outlines the canopy cover measurements at each site for a three year period.

Table 2. Mean canopy cover measures for Elbe Site and Simmons Creek, 1993-1995 surveys. Four equidistant measurements were made within each reach with a canopy densiometer.

	1993	1994	1995
Elbe Site	78%	82%	84%
Simmons Creek	96%	74%	46%

Several biometrics were calculated to describe macroinvertebrate assemblage condition. The biometrics used in this survey are listed in Appendix I and Appendix II. Results of statistical analysis for each biometric which exhibited significant changes at each site are listed in Table 3.

Table 3. Results of inter-annual comparison of biometrics for Elbe Site and Simmons Creek. Significant differences between any two years and the direction of change are listed using the Student's t test.

	1993/94	1994/95	1993/95
Elbe Site			
% Scrapers	not significant	increase ($p=.001$)	increase ($p=.001$)
%Ephemeroptera	not significant	not significant	not significant
%Trichoptera	not significant	not significant	not significant
Simmons Creek			
% Scrapers	decrease ($p=.02$)	not significant	not significant
% Ephemeroptera	increase ($p=.01$)	decrease ($p=.03$)	not significant
%Trichoptera	decrease ($p=.03$)	not significant	not significant

The percentage of scrapers increased during the 1994 and 1995 surveys at Elbe Site. An overall increase of scraper representation was identified at the control site from the beginning of the survey (1993) to the end (1995).

Scraper feeding group representation initially declined at Simmons Creek in 1994 following the clearcut. Overall, no significant difference in proportion of scrapers was found between the 1993 and 1995 surveys at the treatment site. In contrast, the proportion of Ephemeroptera (mayflies) increased significantly following the clearcut and then returned to pre-harvest conditions by the 1995 survey. The percentage of Trichoptera responded to the clearcut with an initial decline, but returned to precut conditions by 1995.

c) Biota of a Type 4 Tributary Stream

A small tributary stream of Simmons Creek was surveyed for benthic macroinvertebrates. The total number of taxa found in the tributary was low (9-17 in multiple samples). These low numbers of taxa precluded calculation and comparison of most of the analytically useful biometrics. More important, were the variety of feeding groups present. Most major feeding groups were found in the small Simmons Creek tributary (collector-gatherers, shredders, omnivores, predators). The collector-filterers were not present. Several shredder taxa were present, two stonefly taxa (Plecoptera) and two caddisfly taxa (Trichoptera). Of these shredders, the stonefly *Pteronarcys* is a long-lived macroinvertebrate (Merritt and Cummins 1996). The collector-gatherers found here are taxa normally associated with sandy and fine gravel substrates. Six predator taxa were also collected. Predators prefer a physically complex environment in which to live.

Discussion of Stream Biotic Condition

a) Effects of the Forest Clearing Treatment

The control site was intended to identify any changes other than those effects resulting from the forest clearing treatment. Changes that occurred in the control assemblage were expected to be identified in the treatment assemblage if forest clearing had no effect on the biology.

The density of scrapers (periphyton consumers) declined at Simmons Creek following the clearcut treatment. With canopy removal, primary production is normally expected to increase. The scrapers feeding group would then directly respond to the increased food availability (Appendix II).

An increase in sunlight and dissolved nutrients (i.e., ortho-phosphate) is necessary to promote periphyton productivity. If nutrient availability were low, canopy removal would not have stimulated a substantial increase in primary production (Murphy and Meehan 1991).

A response in the opposite direction by the scrapers assemblage may have been related to stream size (Murphy and Meehan 1991). As stream size increases the threshold to induce change also increases. Any change in physical or chemical conditions at this stream reach appeared to be partially assimilated below the threshold needed to stimulate primary production.

Scraper density did increase significantly at the control site (Elbe). Understory cover visually appeared to be less dense at the Elbe Site as it was at Simmons Creek. The increase in scraper density at Elbe Site indicated that there may have been greater primary productivity in small streams within the region that had relatively little understory vegetation but greater overhead cover. Primary production appears not to have been influenced by an increase in sunlight penetration (Table 2) following forest clearing at Simmons Creek. A scraper assemblage may require a longer period of time to become dominant and show significant change in this channel.

Mayflies were dominated by two feeding groups at Simmons Creek riffles, collector-gatherers and to a lesser extent, scrapers. The collector-gatherers showed the greatest increase in density following the clearcut. *Baetis spp.* and *Diphetor hageni* both increased in density by the 1994 survey. Their significant increase in abundance indicated that suspended particulates became readily available following the treatment.

Even though the short-term increase of suspended organic material occurred, the contribution to dissolved organic forms must have been negligible. The scrapers did not respond to any increase in production as would have been the expected response from an increase in dissolved organics. Suspended particulates smothering stream-bottom surfaces may also have depressed periphyton growth which was noticeably reduced following treatment. The mayfly assemblages reverted to pre-treatment conditions by responding with a significant decline in density between 1994 and 1995 (Table 3).

The caddisfly (Trichoptera) assemblage significantly declined in density from 1993 to the 1994 survey (Table 3). Most caddisflies at Simmons Creek were scrapers and collector-filterers. Their decline in numbers may have been due to the limited periphyton availability (i.e., scrapers) and the presence of an altered organic suspended particulate size that was not handleable by the hydropsychids present prior to the clearcut treatment. Also, substrate attachment may have become more difficult with any increase in stream bed mobility. The subfamily Hydropsychinae were more abundant than the Arctopsychinae, both collector-filterers, during the pre-treatment survey (1993). Hydropsychinae consume smaller food particulates than do the Arctopsychinae (Wiggins 1996). The Arctopsychinae showed a slight density increase in 1994, but did not compensate for the larger density decline of the Hydropsychinae.

b) Effectiveness of the Forest-Clearing with Buffer Practice

Expected increases in primary productivity would have encouraged the scraper macroinvertebrate density to increase, but nutrient limitation may have suppressed a response. Waters (1995) reported that felling and skidding logs near a stream produced the most detrimental effects on stream assemblages. Road-building near streams also contributes to sedimentation of stream substrates over the longer time period.

It appears that in the absence of road-building close to the Simmons Creek channel and with the removal of timber by yarding outside of a narrow buffer, short-term effects to the macroinvertebrate assemblage were limited, but detectable. Other assemblage changes may not be detectable in this stream channel over this short of a time frame. In the absence of severe flooding, substantial sedimentation, or a streambank failure, the macroinvertebrate assemblage may remain similar to pre-treatment conditions. If revegetation of disturbed areas occurs quick enough to reduce the potential for sedimentation, and if physical channel disturbance is avoided, then no long-term macroinvertebrate assemblage changes would be expected.

The clearcut with buffer technique used at the Simmons Creek site was partially effective. A small response by the macroinvertebrate assemblage indicated there is a potential for adverse effects through an increase in particulate suspended sediments (organic and inorganic).

c) Type 4 Tributary: Biological Significance and Effects of the Clearcut

Several important observations were made from collections in the small tributary of Simmons Creek. The variety of feeding groups found in this stream indicates some stability of the habitat. In frequently disturbed streams the non-specialists dominate the assemblage. These taxa are the collector-gatherers and to some extent the collector-filterers. Predators and shredders require more constancy in the physical stream channel. There were a variety of taxa collected from this small stream representing both feeding groups, indicating stable physical habitat.

Also present in this tributary stream were long-lived stoneflies (*Pteronarcys sp.*). The long developmental time of the nymphal stage indicates that water is continually present in this small stream channel. The food source of this stonefly is deciduous leaves that have been partially conditioned by the microbial community (Stewart and Stark 1988).

Threats to this tributary stream are changes in the surface water flow regime and in the accustomed food source for the existing macroinvertebrate assemblage. Reduction of the water table or changes in the timing of surface flows could eliminate the habitat of the long-lived (3-5 years) stonefly, *Pteronarcys sp.* This length of time to complete an individual life cycle is comparable to that of the salmon (*Oncorhynchus sp.*). Loss of the allochthonous food source (leaf litter) will occur with removal of overhead canopy. Collector-gatherer taxa extract organic material from the stream sediments in this tributary. Alteration of the proportion of organics in the substrate could mean the loss of a food source for several taxa. The increase in sedimentation that occurred in this stream may also smother or dilute food-rich sediments for macroinvertebrates.

Although the number of taxa were too limited to rely on the most useful diagnostic biometrics, notable changes in the macroinvertebrate assemblage were not observed following forest clearing. Therefore, the BMP application was considered to have adequate short-term effectiveness for stream macroinvertebrates.

Conclusion

Small to medium sized streams do not always show immediate effects from forest clearing activities. Many streamside activities can have a negative influence on the biological assemblage. The presence of some combination of such activities can initiate a physical and chemical response. When the stream responds to riparian and watershed changes, the influence on biology may not be immediately identifiable.

Small changes in stream biology can be early indicators of the potential for long-term problems. An early warning in the biological assemblage can be used to decide if other important biological resources require protection. The biological response to forest practice activities can be unique at each stream, but a deductive analytical approach with *a priori* expectations makes bioassessment a useful assessment tool.

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Appendix I

Station	Total taxa	EPT Index	%Plecoptera	%Ephemeroptera	%Trichoptera	%Perlidae	%Dominance(3 taxa)
Elbe Site 1993							
riffle 1	37	29	12.76	24.48	7.2	3.09	54.94
riffle 2	41	27	27.27	3.33	8.48	13.03	60.61
riffle 3	32	18	12.34	11.88	16.48	3.6	52.65
riffle 4	39	26	24.14	7.39	9.36	11.33	37.44
Simmons Creek 1993							
riffle 1	36	24	5.71	24.86	22	.57	48.29
riffle 2	unavailable data						
riffle 3	40	31	11.54	23.64	18.2	1.5	48.45
riffle 4	40	27	14.68	15.44	11.66	2.32	56.53
Elbe Site 1994							
riffle 1	62	39	14.16	9.85	12.58	4.72	49.73
riffle 2	42	23	16.24	14.65	2.38	2.38	45.74
riffle 3	35	21	24.14	7.39	9.36	11.33	37.44
riffle 4	48	28	12.3	17.94	6.26	2.78	37.35
Simmons Creek 1994							
riffle 1	38	26	7.01	58.23	8.23	1.52	60.67
riffle 2	37	25	11.74	50.76	6.06	.51	62.88
riffle 3	52	31	20.1	38.26	10.93	1.93	49.2
riffle 4	36	24	13.84	38.12	10.7	3.39	55.61
Elbe Site 1995							
riffle 1	47	30	20.03	7.59	16.69	9.41	43.85
riffle 2	44	25	25.61	3.81	13.84	10.73	35.64
riffle 3	26	13	7.3	2.23	12.98	4.87	55.42
riffle 4	40	27	20.3	9.25	10.45	4.48	44.27
Simmons Creek 1995							
riffle 1	41	25	28.16	38.58	8.65	.44	38.14
riffle 2	35	28	41.54	17.44	24.1	2.05	43.59
riffle 3	28	19	9.06	30.2	2.01	.34	62.75
riffle 4	46	30	20.36	21.91	37.89	2.58	27.58

Appendix I (Continued)

Station	Total taxa	EPT Index	%Plecoptera	%Ephemeroptera	%Trichoptera	%Perlidae	%Dominance(3 taxa)
Simmons Creek 1993 (tributary)							
sample 1	9	3	28.57	25.0	3.6	0	64.28
sample 2	12	9	56.0	8.0	12.0	4.0	52.0
Simmons Creek 1994 (tributary)							
sample 1	9	3	29.73	24.32	2.7	0	64.86
sample 2	12	8	62.07	6.9	6.9	3.45	72.41
Simmons Creek 1995 (tributary)							
sample 1	17	5	16.67	0	14.10	1.3	47.44

Appendix II

Station	% Scrapers	% Shredders	% Collector-filterers	% Predators
Elbe Site 1993				
riffle 1	4.53	9.67	.4	9.05
riffle 2	4.54	11.82	3.3	28.79
riffle 3	8.78	13.93	0	17.48
riffle 4	7.85	9.84	16.65	15.37
Simmons Creek 1993				
riffle 1	10.86	3.43	21.71	13.71
riffle 2	unavailable data			
riffle 3	10.32	0	8.88	2.16
riffle 4	13.17	9.29	4.64	11.32
Elbe Site 1994				
riffle 1	9.78	8.21	4.7	22.23
riffle 2	11.29	11.48	1.2	13.46
riffle 3	5.42	14.78	2.96	28.08
riffle 4	11.99	7.81	1.24	12.92
Simmons Creek 1994				
riffle 1	8.23	4.27	5.79	5.49
riffle 2	5.93	8.84	.16	8.46
riffle 3	3.38	13.99	5.35	14.31
riffle 4	6.79	9.92	4.15	10.18
Elbe Site 1995				
riffle 1	20.66	8.95	10.17	18.97
riffle 2	21.8	10.38	5.54	25.26
riffle 3	21.7	8.92	2.84	11.76
riffle 4	23.28	14.03	3.88	14.03
Simmons Creek 1995				
riffle 1	19.96	23.72	3.99	9.31
riffle 2	12.82	26.15	17.95	21.54
riffle 3	8.05	6.71	3.02	9.73
riffle 4	36.86	11.34	17.52	13.92

Northern Cascades Physiographic Region

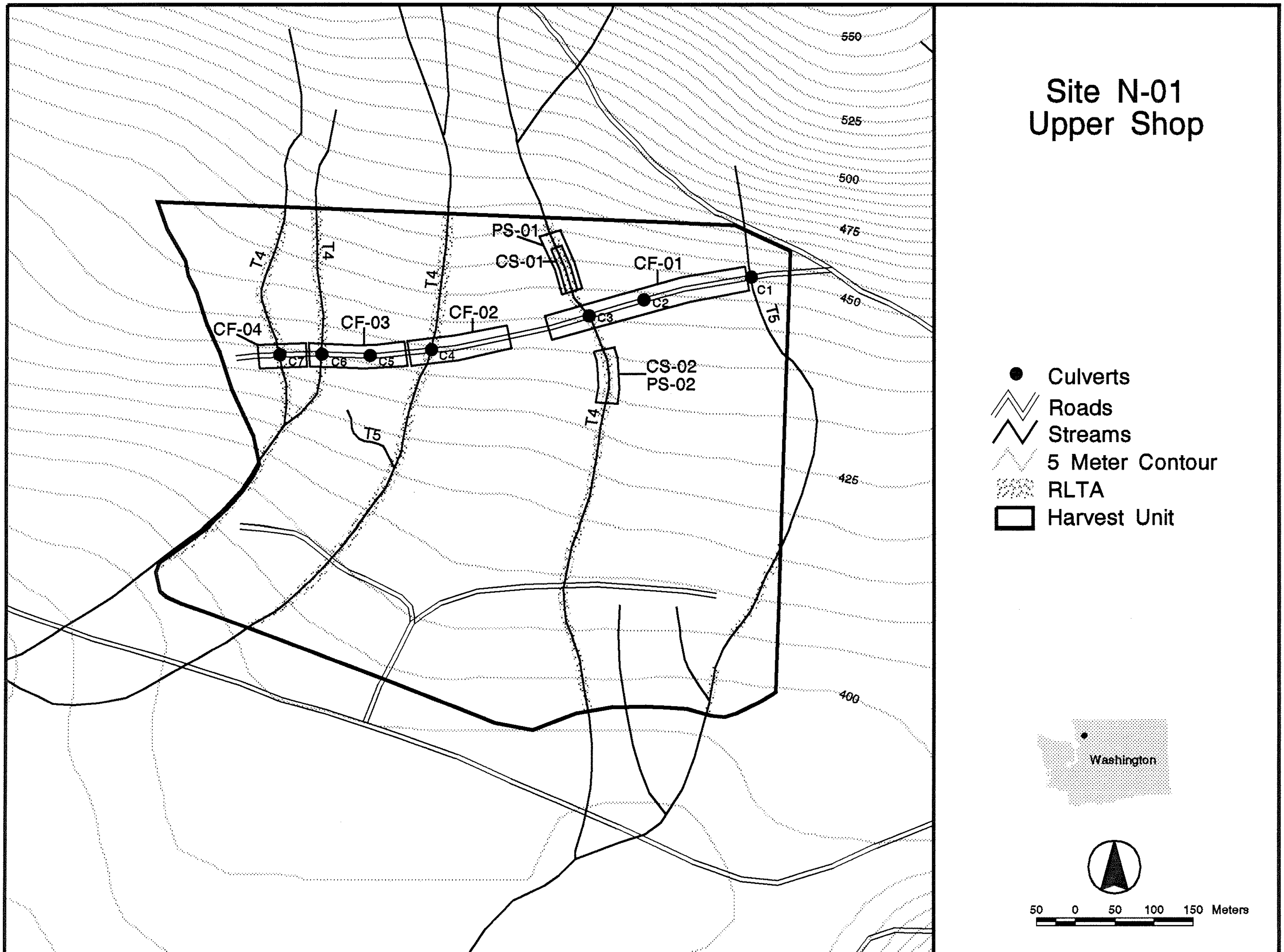
Site N-01: Upper Shop

Upper Shop site is a new road construction and harvest evaluation site located in southwest Skagit County in the Northern Cascades physiographic region. The underlying geology consists of upper Cretaceous metamorphic rocks. The northern one-quarter of the harvest unit is underlain by fine-grained greenschist of the Shuksan Unit, and the surface geology of the southern portion of the site is mapped as black quartz phyllite of the Darrington Unit. Soils at the site are mapped as Sorenson very gravelly silt loam, 3-30% slopes. The disturbed soil slope stability is rated as stable with a moderate hazard for cutbank/fill/sidecast construction and a low erosion potential. The harvest BMP slope hazard category for the site is high, with stream valley side slopes of up to 50% along the study reaches. The road construction BMP slope hazard category is low, with hillslope gradients ranging from 4-20% along the road alignment, but predominantly less than 15%.

There are eight zero order streams within the unit. Three of them are short Type 5 streams that originate within the unit, one of which was not shown on the FPA or DNR Water Type map. Another Type 5 stream originates upstream of the unit and flows a short distance across the northeast corner of unit before exiting, and re-entering the southeast corner of the unit as a Type 4. There are four other Type 4 streams in the unit, one of which was mis-classified as a Type 5 on the FPA. (Note: these streams are upstream of an anadromous barrier at mile 11 of Pilchuck Creek, but may actually be Type 3 based on physical criteria for resident fish use; in the absence of observations on fish presence or summer low flow conditions, they are referred to as Type 4.) All of these streams are tributaries of Pilchuck Creek in the Stillaguamish River basin. In-stream surveys were conducted on one of the Type 4 streams that is crossed by the upper road. The two study reaches on this stream have average active channel widths of about 3 meters with average gradients of 9-10%, and a step-pool channel morphology.

Forest practices conducted at this site include a 46 hectare clearcut harvest with 1.8 kilometers of new road construction. RLTAs were established on all the Type 4 streams within the harvest unit, with adjacent areas harvested by ground-based yarding methods (including shovels). The width of the RLTA in the vicinity of the two Type 4 in-stream survey reaches averaged 5-6 meters. The Type 5 streams were not buffered. The road construction was completed in February 1993, and the harvest completed in April 1993.

The BMPs evaluated at Upper Shop are the new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes), and the RLTA along the Type 4 stream with adjacent ground-based harvesting. Culvert condition surveys that covered five stream crossings and two relief culverts along 744 meters of the upper road in the unit were conducted in July 1993 and May 1994. Four road drainage segments draining to Type 4 stream crossings were evaluated using cutbank/fillslope surveys conducted in July 1993 and May 1994. Two study reaches were established to evaluate in-stream conditions in the Type 4 stream buffered by a RLTA, one upstream and one downstream of the upper road. A suitable off-site control reach was not available for evaluation of harvest practices, due to the differences in stream character upstream of the unit. Channel condition and photo point surveys were conducted on both reaches in July 1993 and June 1994.


Site N-01
Upper Shop
Culverts
Roads
Streams
5 Meter Contour
RLTA
Harvest Unit
Washington
50 0 50 100 150 Meters
550
525
500
475
450
425
400
PS-01
CS-01
CF-01
CF-02
CF-03
CF-04
CS-02
PS-02
C1
C2
C3
C4
C5
C6
C7
T4
T5

Harvest BMP Effectiveness Summary

Study Site: N-01: Upper Shop - Clearcut harvest with RLTA

		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys conducted.						
Case Narrative:	There was no evidence of yarding across the RLTA in the vicinity of stream surveys. Along the study reaches, the RLTA appeared to be a no-cut buffer that extended to the slope break of the inner gorge.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01					Effective	
	CS-02					Effective	
	Photo Point:						
	PS-01					Effective	
	PS-02					Effective	
Case Narrative:	The in-stream surveys evaluated two study reaches on the same type 4 stream buffered by a RLTA. No stream channel disturbance or sediment sources directly associated with timber falling and yarding activities were observed. Increased stream bank erosion associated with windthrow was observed at one location. Photo point surveys documented 14 windthrown trees across the channel over 150 meters of stream surveyed.						
	OVERALL SITE BMP EFFECTIVENESS RATING:					EFFECTIVE	

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Upper Shop: N-01

Treatment Survey ID#: CS-01 & CS-02 Water Type: 4
Control Survey ID#: None

BMP(s) Evaluated: RLTA (Clearcut harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score		Survey Date	Control Score	Survey Date
	CS-01	CS-02			
Initial Surveys*:	62	55	7/13/93	n/a	
Post-Treatment Survey #1:	60	57	6/1/94	(No site-specific Control Reach was available for this site.)	
Change from Pre-Treatment Score:	-2	+2			
Net Change (Control-Treatment):	n/a				

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
[Note: Initial surveys were conducted approximately 3 months following harvest operations, rather than before treatment. No direct effects of timber falling or yarding activities were apparent at this time.]

The CS-01 and CS-02 treatment reaches have a step-pool morphology with average channel gradients of 10% and 9%, respectively, with stable steps formed by old cedar woody debris (both natural and cull logs). Active channel width within the CS-01 and CS-02 survey reaches are 2.5 meters and 3.2 meters, respectively. These streams are upstream of an anadromous barrier at river mile 11 on Pilchuck Creek, but the CS-01 and CS-02 reaches may actually be type 3 based on the physical criteria for resident fish use (e.g. channel gradient and width). In the absence of field observations on summer low flow discharge or fish use, both reaches are referred to as type 4. The channel condition score decreased by 3% in the upper, CS-01 reach, but increased by 4% in the lower reach. Minor changes noted in the CS-01 reach were a reduction in the extent of fresh sediment deposits (increase in score) offset by an increase in the extent of fines in pools. Within the CS-02 reach below the road, changes include a increased flow deflection into banks, offset by decreases in the extent of bank erosion and the extent of fresh sediment deposits and non-pool surface fines.

In-Stream Photo Point Survey Summary

Site: Upper Shop
Survey Id: PS-01
Water Type 4

Survey dates:
7/13/93 & 6/1/94
Reach Length: 75m.

Treatment Reach (no control comparison).

Indicators of in-channel changes	Yes	No	Photo/Field Note References 1992	1993	1994
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks? *(a single cedar windthrow at streambank)	X*	X**		*@ P1:Photo 2 **(remainder of reach)	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		Photo 23	Photo 11
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X		Photo 16	Photo 3
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X		Photo 16	Photo 3
5. Are there changes in woody debris?					
Increase in large WD?	X***			Photo 22	Photo 10
Increase in small WD	X			Photo 22	Photo 10
Decrease in WD?		X			
***(Survey documents 2 new WT in '93 plus 4 additional WT trees in '94 over the length of this reach.)					
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X			

Summary:

This survey is located within a type 4 stream which was buffered with an RLTA within a clearcut harvest unit. The initial survey was conducted approximately three months following the harvest. There were no obvious effects of the harvest activities on the stream channel at the time of the initial survey. Between the 1993 and 1994 surveys the channel appeared to change little. The most noticeable change was in vegetation along the channel margins and colonizing sediment wedges and bars. Where in 1993 no grasses were observed, 1994 showed lush growth of grasses all along the stream corridor. This new growth obscured a large proportion of the streambed from view in the 1994 survey. The increase in stream bank erosion was from one windthrow along the stream bank near photo point 1. Other changes include 6 windthrown trees observed within the window of the photo perspectives over the study period over the 75 meter reach, which was a relative low rate of windthrow compared to other clearcut harvest units evaluated in this study.

BMP Effectiveness Rating: EFFECTIVE

In-Stream Photo Point Survey Summary

Site: Upper Shop
Survey Id: PS-02
Water Type 4

Survey dates:
7/13/93 & 6/1/94
Reach Length: 75m.

Treatment

Indicators of in-channel changes	Yes	No	Photo/Field Note References 1992	1993	1994
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X			
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)? * small woody debris jam gone.		X		Photo 3	Photo 10
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)? *(fresh fines noted on revegetating sediment wedges and a bank deposition area during both years.)	X*	X		Photos 9,12 Photos 1,2,5	Photos 18,20 Photos 8,9,14
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X		Photo 1	Photo 8
5. Are there changes in woody debris?					
Increase in large WD?	X*			Photo 4	Photo 11
Increase in small WD	X			Photo 3, 4	Photo 9,11
Decrease in WD?		X			
*(Survey documents 4 new WT trees in '93 plus 4 additional WT trees in '94 over the length of this reach.)					
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X	revegetation of channel noted at several points.		

Summary:

This survey is located within a type 4 stream which was buffered with an RLTA within a clearcut harvest unit. It is on the same stream as PS-01, but is downstream of the road at culvert C3. The initial survey was conducted approximately three months following the harvest, and 5 months after road construction. Since the initial survey was conducted 5 months after road construction, and given that road-related sediment was observed in the upper part of the reach at this time and there is no control reach, this survey will not be used to evaluate road effects. Within the upper part of the reach closest to the road crossing, there were observations of fresh fines deposits during both years, but with substantial revegetation occurring the second year. If anything, there was a decrease in fine sediment and fresh deposits over the study period. There were no obvious effects of the harvest activities on the stream channel at the time of the initial survey. Between the 1993 and 1994 surveys the channel appeared to change little with the exception of increased vegetation (primarily grasses) along the channel margins and colonizing sediment wedges and bars. Other changes include 8 windthrown trees observed over the study period within the window of the photo perspectives over the 75 meter reach.

BMP Effectiveness Rating: EFFECTIVE

Road BMP Effectiveness Summary

Study Site: N-01: Upper Shop - New Road Construction

	Survey Employed	Culvert BMPs: Stream Xings (WAC 222-24-040)	Culvert BMPs: Relief (WAC 222-24-025)	Road Construction BMPs: Cutslopes (WAC 222-24-030)	Road Construction BMPs: Fillslopes (WAC 222-24-030)
	BMP Effectiveness Ratings				
	Culvert Condition:				
	CC-01	Effective	Partially Effective		
	Cutbank/Fillslope:				
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	CF-01			Not Effective	Effective
	CF-02			Not Effective	Effective
	CF-03			Not Effective	Effective
	CF-04			Not Effective	Effective

Case Narrative: Culvert condition surveys found that one of the two relief culverts (C5) delivered sediment to a type 5 stream (tributary to the type 4 stream crossed by culvert C4), via a 100 meter channel that developed downslope of the relief outfall. Stream crossing culverts are rated effective because chronic erosion was limited to negligible amounts. The effectiveness of stream crossing BMPs is attributed to a combination of extensive armoring with large rock and vigorous natural revegetation on relatively short culvert fills (fill heights of 1.5 to 3 meters). Three of the five stream crossings were observed to have culvert outfalls hanging above the streambed, at elevations of 0.3 to 0.5 meters. Although natural revegetation of the relatively short cutslopes (average cutslope height of 2 meters, with a maximum height of 4 meters) was vigorous in places, gully formation on cutslopes and ditch scour became sources of chronic erosion with sediment delivery in the four drainage segments evaluated. In the CF-02 segment, slumping of the cutslope at the stream crossing was also observed, with direct delivery to the stream. In the CF-01 segment, disturbance of cutslopes during ground-based timber yarding operations was noted as a factor in gully formation. In all four road drainage segments, it was noted that cutslopes and ditches intercepted substantial amounts of sub-surface flow, with numerous flowing seeps observed as factors contributing to gully formation. Chronic erosion of fillslopes was also observed, but any delivery from fillslope erosion was limited to the immediate vicinity of stream crossings where they were well-armored.

ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).

No separate in-stream surveys were employed in the evaluation of road effects.

Case Narrative: In-stream surveys conducted upstream and downstream of one of the road crossings were used to evaluate harvest practices at this site, but are not included in the evaluation of road effects because of the timing of preliminary surveys and the lack of a control site. However, it was during the preliminary channel condition and photo point surveys downstream of the road crossing (conducted 5 months following road construction) that fresh, road-related sediment deposits were affecting the upper half of the study reach. In follow-up surveys conducted 16 months after road construction it was observed that this sediment had either been stabilized by revegetation of channel margin areas or transported downstream.

OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE	PARTIALLY EFFECTIVE	NOT EFFECTIVE	EFFECTIVE

Upper Shop Culvert Condition Survey Results

Site: N-01: Upper Shop
Culvert Condition Survey CC-01

Survey dates: 7/12/93 & 5/13/94
Date of Construction : 2/93

Site BMP Effectiveness Rating:
Stream X-ings: Effective
Relief Culverts: Partially Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year		Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No))
		1993	1994						
C-1	Inflow	Slight	None	107m	Decrease	No			
T-5 x-ing	Outflow	Slight	Slight	(107m)	Constant	Negligible		Negligible	Yes*
C-2	Inflow	None	None	177m	None	No	Yes, 12m down slope		
Relief	Outflow	Moderate	Slight	(177m)	Decrease	Yes		No	Yes
C-3	Inflow	None	None	82m	None	No			
T-4 x-ing	Outflow	Slight	Slight	(138m+)	Constant	Negligible		Negligible	Yes*
C-4	Inflow	Slight	None	173m	Decrease	No			
T-4 x-ing	Outflow	None	None	(147m)	None	No		No	Yes
C-5	Inflow	Slight	Slight	81m	Constant	Yes	Yes, 100m down slope	Yes	
Relief	Outflow	None	None	(51m)	None	No		Type 5/4	No
C-6	Inflow	Slight	Slight	62m	Constant	Negligible			
T-4 x-ing	Outflow	Slight	None	(72m+)	Decrease	No		Negligible	Yes*
C-7	Inflow	None	None	62m	None	No			
T-4 x-ing	Outflow	None	Slight	(66m)	Increase	Negligible		Negligible	Yes*

Comments/ Notes Summary:

* Although there were slight levels of continuing erosion at four of the stream crossing culvert fills, the amount of chronic sediment delivery to streams was considered negligible because of the short fill heights (1.5-3 meters high), and because extensive armoring of the culvert fills with large rock minimized the potential for continued erosion.

The average distance between culverts was 106 meters, with an average road gradient of 3 % and an average hillslope gradient of 12 %; the range of the hillslope gradients along the road alignment was 4-20 %. A total of 14 armoring effectiveness calls were made at the inflows and outflows to the 7 culverts--the armoring was rated "good" at 9, "fair" at 4, and "poor" at 1. The armoring material was large rock, which made the fills resistant to erosion. At the outflows of culverts 3 and 6, some material used to armor the culvert fill was placed in the channel, presumably to dissipate energy and reduce channel erosion. At culvert 5, the newly formed channel traverses under a slash pile and flows 100 meters across the hillslope to type 5 stream, which then flows to the type 4 stream crossed by culvert 4. The gradient of the new channel was measured at 16 %. During the initial survey in 1993, the relief drainage had channelized to the slash pile, but not beyond it. Relief culverts 2 and 5 only partially relieved ditch flow. It appeared that flow in the ditches was perennial due to interception of shallow groundwater.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Upper Shop
Survey Id #'s	CF-01
Survey Dates	7/12/93 & 5/31/94
Water Type	Type- 4
Road Construction Date:	2/93
Length of Road Draining to Stream	312 meters

Range Road Gradient	1-3%
Average Road Gradient	2 %
Range Hillslope Gradient	4-20 %
Average Hillslope Gradient	11%
Range Cutslope Gradient	15-50 deg.
Average Cutslope Gradient	34 deg.

	Cutslopes	Fillslopes
% Observations w/short slope height	100	100
% Observations w/med. slope height	0	0
% Observations w/high slope height	0	0

	Cutslopes 1993	Cutslopes 1994	Fillslopes 1993	Fillslopes 1994
% Observations w/0-25% exposed soils	38	63	63	75
% Observations w/26-50 % exposed soils	38	37	37	25
% Observations w/51-75 % exposed soils	0	0	0	0
% Observations w/76-100 % exposed soils	14	0	0	0
% Observations w/Evidence of Erosion	100	100	87	87
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	no
BMP Effectiveness Rating:	**Not Effective**		**Effective**	

COMMENTS:

This road segment drains to culvert C-3 at a type -4 crossing, and includes a relief culvert (C2). The relief culvert was noted as not providing full relief to the ditch flow along this road segment. In both years it was observed that a type-5 seep/stream at observation point P5 was flowing and incising a channel on the cutslope. Flow from this Type-5 water was diverted to the Type-4 stream at the crossing via the drainage ditch at the base of the cutslope. Numerous other seeps were observed along the cutslope with the ditch having flowing to standing water during survey times. Exposed soils in 1994 were noted to have good natural re-vegetation from rushes, grasses, shrubs and cottonwood tree saplings. Evidence of erosion for cutslopes for both years ranged from minor sheetwash erosion to gully development, and disturbance by timber yarding (equipment ruts), and gullying at seeps. Fill slopes had only minor surface erosion for both survey years. Storage was noted in the ditch for cutslopes and in the slash for fill slopes. The magnitude of chronic erosion and sediment delivery at this site was limited by the short cutslopes, resulting from a road location on relatively flat ground.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Upper Shop
Survey Id #'s	CF-02
Survey Dates	7/12/93 & 5/31/94
Water Type	4
Road Construction Date	2/93
Length of Road Draining to Stream	135 meters

Range Road Gradient	2-6%
Average Road Gradient	4 %
Range Hillslope Gradient	13 %
Average Hillslope Gradient	13%
Range Cutslope Gradient	20-44 deg.
Average Cutslope Gradient	31 deg.

	Cutslopes	Fillslopes
% Observations w/short slope height	100	100
% Observations w/med. slope height	0	0
% Observations w/high slope height	0	0

	Cutslopes 1993	Cutslopes 1994	Fillslopes 1993	Fillslopes 1994
% Observations w/0-25% exposed soils	25	75	100	100
% Observations w/26-50 % exposed soils	50	25	0	0
% Observations w/51-75 % exposed soils	0	0	0	0
% Observations w/76-100 % exposed soils	25	0	0	0
% Observations w/Evidence of Erosion	75	100	0	100
Evidence of Erosion w/delivery to surface water	yes	yes	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	no
BMP Effectiveness Ratings:	**Not Effective**		**Effective**	

COMMENTS:

Only minor erosion was noted in 1993 on the cutslope with none noted for the fillslopes. Storage in the ditch was minimal, as the ditch was noted to have been scoured. In 1994 numerous seeps were observed along the cutslope with the ditches having flowing water. At the stream crossing, the cutslope was slumping into the active stream channel. Other signs of erosion in 1994 included sheetwash erosion and minor gullying. The fillslope was also noted as having sheetwash erosion and gully formation, but no delivery to the stream. There was some storage of cutslope erosion in the ditch, but also continuing ditch scour. Fillslopes were noted as storing sediment in the logging slash. The magnitude of chronic erosion and sediment delivery at this site was limited by the short cutslopes, resulting from a road location on relatively flat ground.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Upper Shop
Survey Id #'s	CF-03
Survey Dates	7/12/93 & 5/31/94
Water Type	4
Road Construction Date:	2/93
Length of Road Draining to Stream	121 meters

Range Road Gradient	3-4%
Average Road Gradient	3.5 %
Range Hillslope Gradient	12-15%
Average Hillslope Gradient	13%
Range Cutslope Gradient	16-34 deg.
Average Cutslope Gradient	25 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	100		100	
% Observations w/med. slope height	0		0	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	25	75	67	100
% Observations w/26-50 % exposed soils	25	0	33	0
% Observations w/51-75 % exposed soils	50	25	0	0
% Observations w/76-100 % exposed soils	0	0	0	0
% Observations w/Evidence of Erosion	100	100	67	50
Evidence of Erosion w/delivery to surface water	yes	yes	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	no
BMP Effectiveness Ratings:	**Not Effective**		**Effective**	

COMMENTS:

This road segment drains to culvert C-6 at a type 4 stream crossing, and includes a relief culvert (C5), which also delivered road drainage to a type 5 stream located downslope of the relief outfall. The relief culvert was noted as not providing full relief to the ditch flow along this road segment. Minor surface erosion and gully formation was noted in 1993 on the cutslope, with only minor surface erosion for the fillslopes. Storage was observed in the ditch for cutslopes and in slash for fillslopes for both 1993 and 1994 surveys. Numerous seeps were observed along the cutslope and two were observed on the fillslopes. In 1994, gully erosion was noted on cutslopes, especially at seep discharges. As in the other CF surveys at this site, vigorous natural re-vegetation was observed on both the cutslopes and fillslopes between the first and second survey years. The magnitude of chronic erosion and sediment delivery at this site was limited by the short cutslopes, resulting from a road location on relatively flat ground.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Upper Shop
Survey Id #'s	CF-04
Survey Dates	7/12/93 & 5/31/94
Water Type	4
Road Construction Date:	2/93
Length of Road Draining to Stream	65 meters

Range Road Gradient	0-5%
Average Road Gradient	3%
Range Hillslope Gradient	11-14%
Average Hillslope Gradient	12.5%
Range Cutslope Gradient	25-34 deg.
Average Cutslope Gradient	30 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	100		100	
% Observations w/med. slope height	0		0	
% Observations w/high slope height	0		0-	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	33	50	50	50
% Observations w/26-50 % exposed soils	0	50	50	50
% Observations w/51-75 % exposed soils	33	0	0	0
% Observations w/76-100 % exposed soils	33	0	0	0
% Observations w/Evidence of Erosion	100	100	50	100
Evidence of Erosion w/delivery to surface water	yes	yes	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	yes	yes	no	minor slump
BMP Effectiveness Ratings:	**Not Effective**		**Effective**	

COMMENTS:

In 1993 evidence of cutslope erosion ranged from minor sheetwash erosion to gully development. For fillslopes erosion was noted as minor sheetwash erosion. Storage of sediment for cutslopes was observed in logging slash and some in the ditch. The ditch was noted to have been scoured. For fillslopes storage was in the logging slash. Types of erosion observed in 1994 for cutslopes included slumping, gullying, and ditch scour, with fillslopes noted as having minor surface erosion. Storage for cutslope was partially in the ditch, but with continuing ditch scour. On fillslopes in 1994 storage was in logging slash. Several seeps were noted on the cutslope in 1993 and 1994 with one seep noted on the fill in 1993 but not in 1994. As in the other CF surveys at this site, vigorous natural re-vegetation was observed on both the cutslopes and fillslopes between the first and second survey years. The magnitude of chronic erosion and sediment delivery at this site was limited by the short cutslopes, resulting from a road location on relatively flat ground.

Site N-02: Pilchuck Mainline

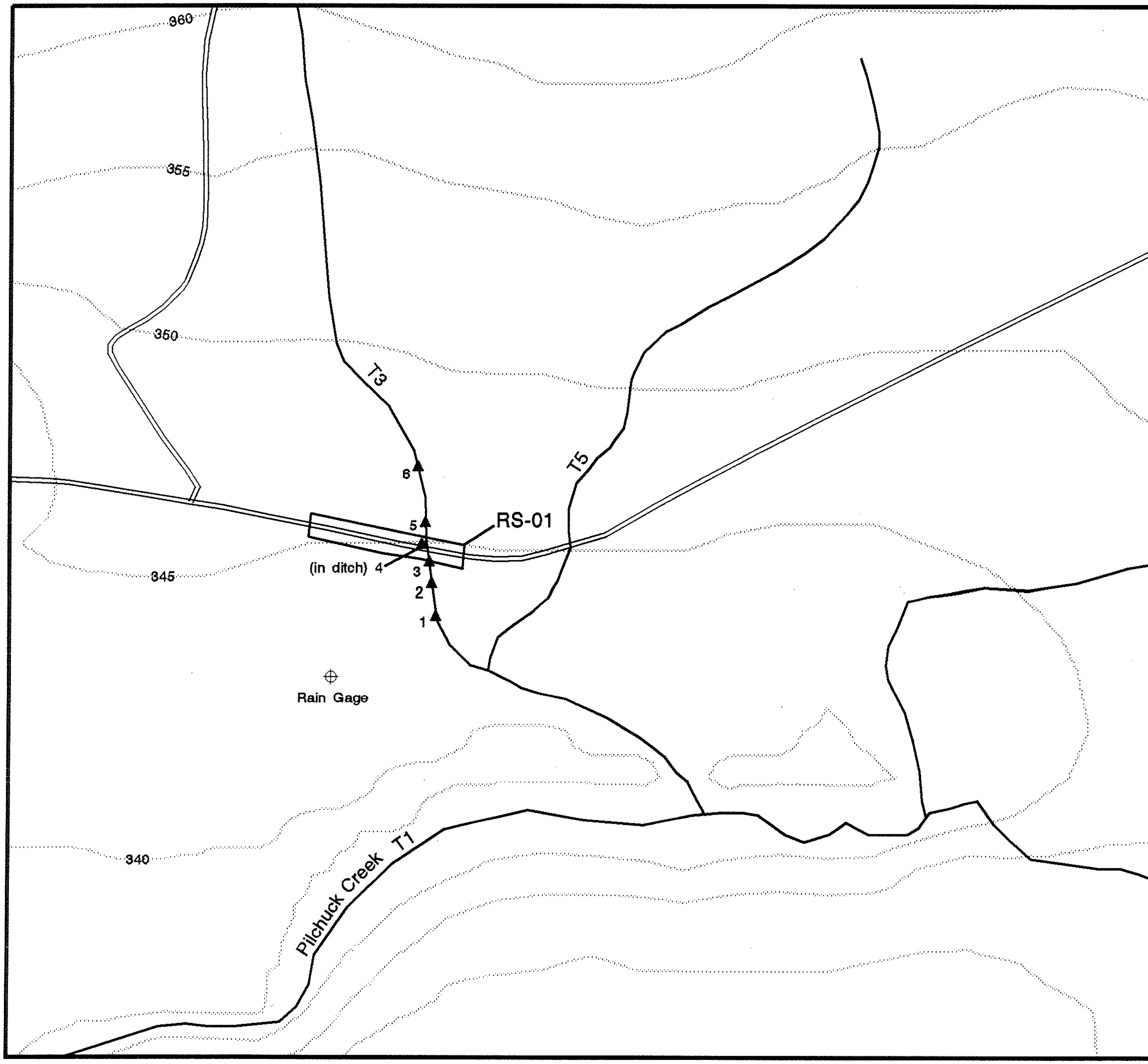
The Pilchuck Mainline site is an active haul road located in south-central Skagit County in the Northern Cascades physiographic region. The surface geology of the site is classified as recessional glacial outwash deposits of the Vashon stage, consisting primarily of stratified sands and gravels. Soils at the study site are mapped as Saxon silt loam, 0-30% slopes. These soils are rated as stable for disturbed slopes with a moderate cutbank/fill/sidecast hazard and a low erosion potential. Hillslope gradients are generally flat in the study area.

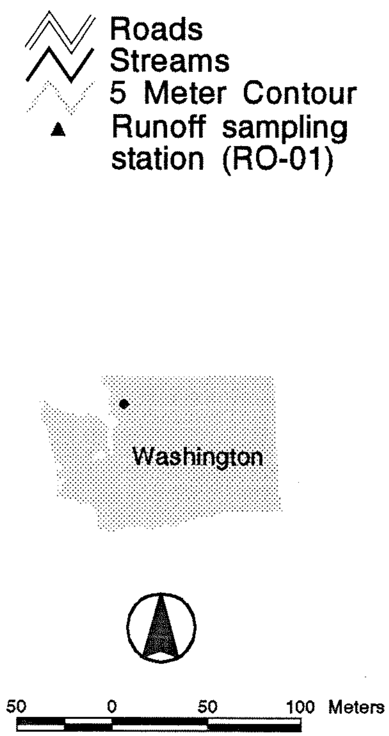
The study stream crossed by the haul road is a 2nd order, Type 3 tributary to Pilchuck Creek, in the Stillaguamish River basin. The study reach established downstream of the road crossing has step-pool/pool-riffle channel morphology, with an average active channel width of 8 meters and an average stream gradient of 3%. The control reach on the same stream upstream of the road crossing has a pool-riffle morphology, with an average active channel width of 8 meters and an average stream gradient of 2%.

Active, mainline haul road maintenance BMPs were evaluated at this site. The road segment surveyed was the near-stream portion of a relatively flat drainage segment that included 186 meters of mainline road, plus additional drainage from a spur road. The study stream drains beneath the road via a 1.8 m diameter culvert. The road at the stream crossing is crowned with ditches, and berms on the side that is slightly downslope. Fillslopes and ditches were well-vegetated; there were no appreciable cutslopes along the survey segment due to the flat topography of the site. Maintenance schedules varied according to traffic volume, weather conditions, and road-bed integrity. Regular maintenance activities consisted primarily of grading. At the time of the field surveys, a layer of sand had been placed to cover a layer of abrasive rock surfacing in order to prevent tire damage. It did not appear that ditch clean-out in the vicinity of the study site occurred on a regular basis: grasses and shrubs were well established to the edge of the running road surface.

In-stream sampling reaches were established just upstream and downstream of the road crossing. Channel condition surveys were conducted on both reaches to evaluate in-stream sediment sources and comparability of the study reaches. Runoff sampling and road surface condition surveys were conducted at the site during a rainfall/runoff event in April 1994.

Site N-02
Pilchuck Mainline





Active Haul Road Maintenance BMP Effectiveness Summary

Study Site:	N-02: Pilchuck Mainline	
	Survey Employed	**BMP Effectiveness Ratings** Active Haul Road Maintenance WAC 222-24-050(2) & (4)
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Road Surface Condition: RS-01	Effective
Case Narrative:	The road segment surveyed was the near-stream portion of a drainage segment that included 186 m of mainline road, plus some additional drainage from a spur road. This road segment was surveyed during a single runoff event during April 1994. Weather conditions during the survey were characterized by intermittent heavy rain and periods of light rain. The on-site rain gage recorded a cumulative total of 20.1 mm falling over a 7 hour period. During one part of the day 18 mm of rain was recorded in just over 2 hours. Runoff on the road surface and in ditches was observed. The road did not have a competent gravel surface at the time of the survey. The travelway surface consisted of a layer of sand that had been temporarily placed to cover a layer of abrasive rock surfacing that had caused problems by damaging tires. However, the road surface condition survey resulted in a call of "Effective" because excessive generation of fines or other problematic conditions leading to water quality impacts were not observed. The thickness of fines on the road surface ranged from less than 0.5 cm to 5 cm, but the majority of measurements were less than 0.5 cm. on the travelway. Minor potholes (<0.2 m) and minor rutting were noted at some transects. The outer sides of ditches and fill slopes were well-vegetated. There were no appreciable cut slopes due to the flat topography of the site. The sampled segment was crowned, with a berms running along the side that was slightly downslope. Traffic on the day of sampling included 12 loaded log trucks, 10 unloaded log trucks and 12 light vehicles over a 7 hour period.	
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Runoff Sampling: RO-01	Effective
Case Narrative:	Water sampling indicated transport of fine sediment in ditches, with turbidity levels of 8-25 NTU, compared to 3-7 NTU in the ambient stream water. Total suspended solids concentrations were also elevated in the ditch flow relative to the stream (32-56 mg/l in the ditch versus 1.9-4.3 mg/l in the stream. However, the observed effects of this road drainage on turbidity and total suspended solids (TSS) levels in the stream were limited and transient, based on sampling above and below the road. Ambient conditions in the stream upstream of the road were characterized by turbidity of 5-6 NTU and TSS of 3.1-3.3 mg/l during a rainy period in the morning, while below the road crossing turbidity was 6-7 NTU and TSS concentrations were 3.7-4.3 mg/l during the same period, indicating a slight increase associated with the road drainage. During a lull in the rainfall in the afternoon, turbidity was 3-6 NTU upstream and 4 NTU downstream, and TSS was 1.9-2.9 mg/l upstream and 1.9-2.4 mg/l downstream. Stream discharge measurements taken on the day of sampling indicated that streamflow downstream of the road was higher than upstream. The stage height recorder malfunctioned, but manual readings showed a stage increase of 3 cm from morning to afternoon, confirming that this was a runoff event.	
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE

Eastern Cascades Physiographic Region

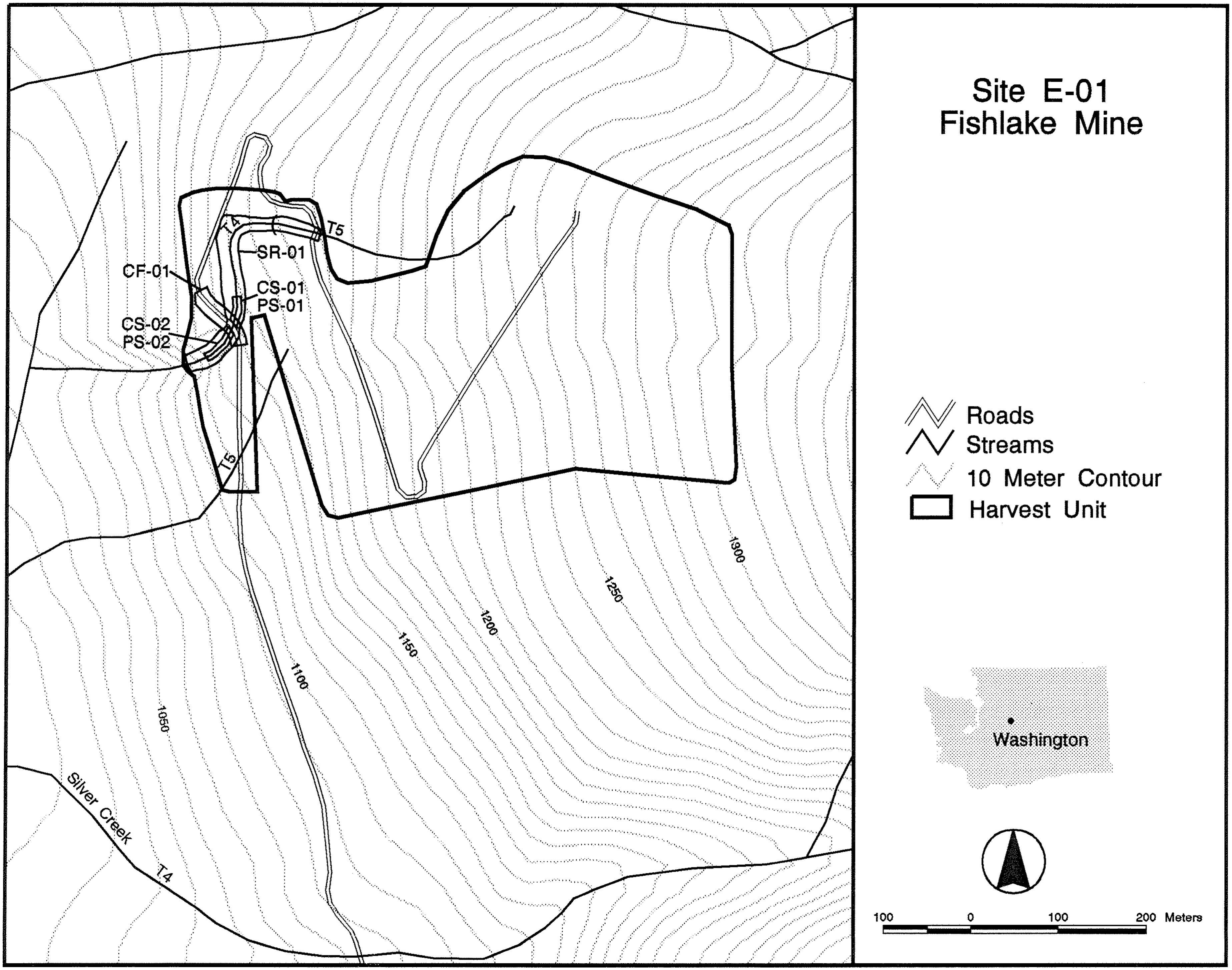
Site E-01: Fish Lake Mine

The Fish Lake Mine site is located in north-central Kittitas County in the Eastern Cascades physiographic region. Both harvest and new road construction practices were evaluated at this study site. The surface geology of the site is metamorphic rock of the Ingalls tectonic complex, primarily serpentine. Soils at the study site are mapped as Waptus very stony sandy loam, 45-65% slopes. The soils are rated as very unstable for disturbed slope stability, with a severe cutbank/fill/sidecast hazard and a high erosion potential. Based on stream valley side slope gradients of up to 53% measured in the vicinity of survey areas, the harvest BMP slope hazard category is high. The road construction BMP slope hazard category is moderate, with slope gradients of 12-45% at the stream crossing, and 29-47% along the rest of the road segment surveyed.

The study stream at this site is a zero order, Type 4 tributary to Silver Creek in the Cle Elum River basin. In the upper reaches of the survey areas, the stream changes to a Type 5. Two in-stream survey reaches on the Type 4 stream have a step-pool morphology, with average active channel widths of 1.5 to 2 meters, and average gradients of 12% and 17%.

Forest practices conducted at the Fish Lake Mine site include a 24 hectare partial cut harvest, with 75% volume removal. 2.4 kilometers of new road were constructed to access the harvest unit. Temporary log and culvert crossings were installed across the Type 4 stream and the upper Type 5 reach. Road construction was completed by the end of August 1992. The harvest was completed in September 1993. The temporary crossings had been removed by June 1994.

BMPs evaluated at the site include partial cut harvesting using cable yarding methods in the vicinity of the Type 4/5 stream without stream buffers, as well as new road construction practices, including temporary water crossings and road construction techniques (cut and fill slopes). Two study reaches were established on the Type 4 stream; one upstream of the temporary crossing and the other downstream. Preliminary channel condition and photo point surveys were conducted in August 1992, concurrent with road construction and about a year before the harvest occurred. The area in the vicinity of the study reaches was harvested before follow-up surveys to evaluate road effects could be conducted, so the in-stream surveys were used primarily for a before/after comparison of harvest effects. Follow-up in-stream surveys were conducted in October 1993 and August 1994. Sediment routing surveys were conducted along the Type 4/5 stream in June 1994 and October 1995. Cutbank/fillslope surveys were conducted along the segment of the road draining to the temporary crossing of the Type 4 stream in October 1993 and August 1994, with follow-up observations of the temporary crossing sites in October 1995.



Site E-01
Fishlake Mine
Roads
Streams
10 Meter Contour
Harvest Unit
Washington
100
0
100
200 Meters
SR-01
CF-01
CS-01
PS-01
CS-02
PS-02
T4
T5
T5
1050
1100
1150
1200
1250
1300
Silver Creek
T4

Harvest BMP Effectiveness Summary

Study Site: E-01: Fish Lake Mine - Partial cut harvest without stream buffers.

		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
	Sediment Routing:						
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	SR-01				Not Effective		

Case Narrative: The sediment routing surveys documented substantial sediment delivery to and disturbance of the Type 4 stream (Type 5 in the upper reaches within the harvest unit). Erosion and sediment delivery was greatest in two zones where timber was yarded diagonally across the stream, disturbing banks and valley walls. At the time of the first survey (9 months following harvest), disturbed soils covered 24% of the survey area, with all but 0.5 m^2 of this erosion caused by timber harvest activity. A substantial amount of natural revegetation of disturbed areas had occurred by the follow-up survey conducted 25 months after harvest, with soil disturbance reduced to 4 % of the survey area, but half of the harvest erosion features that were found to deliver the first year were continuing to deliver sediment to the stream, and stream bank sloughing was continuing in an area disturbed by falling and yarding activities.

	Survey Employed	Ground-based Yarding (RMZ)	Cable Yarding (RMZ)	Ground-based Yarding (no buffers)	Cable Yarding (no buffers)	Ground-based Yarding (RLTAs)	Cable Yarding (RLTAs)
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01				Not Effective		
	CS-02				Not Effective		
	Photo-Point Survey:						
	PS-01				Not Effective		
	PS-02				Not Effective		

Case Narrative: The channel condition and photo point surveys documented degradation in the Type 4 stream associated with harvest activities, including stream bank erosion caused by direct physical disturbance during yarding operations, increases in fresh sediment deposits, increased streambed mobility and destabilization of sediment storage elements (e.g., sediment wedges formed by natural woody debris), and slash and cull logs left in the channel causing flow deflection onto banks. It was observed during pre-treatment surveys that there was no evidence of previous timber harvesting in the survey areas.

OVERALL SITE BMP EFFECTIVENESS RATING:				NOT EFFECTIVE		

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Fish Lake Mine	Survey Date	6/14/94
Site Id #	E-01	Survey Id #	SR-01
Water Type	4/5	Months Since Harvest:	9

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	yes	1.6	0-25	0.2
2	yarding	no	17.3	0-25	2.2
3	old windthrow	yes	0.5	0-25	0.1
4	yarding	yes	22.5	0-25	2.8
5	yarding	yes	35.0	0-25	4.4
6	yarding	yes	36.0	0-25	4.5
7	landing	no	40.0	75-100	35.0
8	yarding	yes	1746.0	0-25	218.3
9	landing	yes	158.4	50-75	99.0
10	yarding	yes	340.0	0-25	42.5
11	falling/yarding	yes	38.6	25-50	14.5
TOTALS		9 delivered	2435.9		423.5

Total Area of Ground Surveyed = 1.0 hectare

Total Length of Stream Bank Surveyed = 742 meters

Disturbed Soil per Hectare = 2435.9 m^2./hectare

Exposed Soil per Hectare = 423.5 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 386.3 $meters^2$

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 386.3 m^2/hectare

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 386.2 $meters^2$**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 386.2 m^2/hectare**

* Features that delivered but are not directly attributable to current harvest activities, such as windthrow, are excluded from these calculations

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Yarding	7	274.9	272.7	70.6
Falling/Yarding	1	14.5	14.5	3.8
Landing	2	134.0	99.0	25.6
Old Windthrow	1	0.1	0.1	<0.1

NARRATIVE:

The forest practices evaluated with this survey were partial cut harvesting using cable yarding methods (possibly assisted by skidders) in the vicinity of un-buffered type 4 stream (was type 5 in the upstream reaches of the survey area). The survey proceeded down the valley of the un-buffered type 4 stream, from just below the upper road crossing to the downstream limit of the harvest unit. Both sides of the stream were covered. (Note: two erosion features associated with temporary culvert installations were documented and measured during the survey, but are excluded from the sediment routing summary which is focused on harvest-related erosion features. Information on these road crossing features is considered in the road evaluation at the same study site.) 82% of the erosion features identified in the survey delivered sediment to the stream. All of these were within 10 meters of the stream. 91% of the total exposed soil area documented in the survey is from features that delivered. Most of the erosion associated with sediment delivery was caused by yarding activities very near to or crossing the stream or on the stream valley slopes. Falling and yarding activities conducted within and crossing the un-buffered type 4 stream also resulted in disturbance of upper and lower stream banks.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Fish Lake Mine	Survey Date	10/3/95
Site Id #	E-01	Survey Id #	SR-01
Water Type	4/5	Months Since Harvest	25

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	yarding	no longer eroding - revegetated			
2	yarding	no	17.3	0-25	2.2
3	old windthrow	yes	1.0	75-100	0.9
4	yarding	no longer eroding - revegetated			
5	yarding	no	1.5	75-100	1.3
6	yarding	yes	9.2	25-50	3.5
7	landing	no	40	50-75	25.0
8(a)	yarding	yes	8.4	0-25	1.1
8(b)	yarding	no	61.6	25-50	23.1
9	landing	no	158.4	25-50	59.4
10	yarding	yes	24.8	0-25	3.1
11	falling/yarding	yes	26.4	50-75	16.5
	TOTALS	5 delivered	348.6		136.1

Total Area of Ground Surveyed = 1.0 hectares

Total Length of Stream Bank Surveyed = 742 meters

Disturbed Soil per Hectare = 348.6 m^2/ha.

Area Exposed Soil per Hectare = 136.1 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 25.1 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 25.1 m^2/ha.

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 24.2 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 24.2 m^2/ha.**

* Features that delivered but are not directly attributable to current harvest practices, such as windthrow, are excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
yarding	6	34.3	7.7	30.7
falling/yarding	1	16.5	16.5	65.7
landing	2	84.4	0.0	0.0
old windthrow	1	0.9	0.9	3.6

NARRATIVE:

Forest practices evaluated at this site were partial cut harvesting using cable yarding methods (possibly assisted by skidders) in the vicinity of an un-buffered type 4 stream (was type 5 in the upstream reaches of the survey area). Four of the 8 erosion features associated with yarding and falling activities within the channel and on the lower stream valley slopes that were delivering sediment to the stream in the 1994 survey conducted 9 months following harvest, continued to deliver in 1995, although the extent of erosion was greatly reduced due to natural revegetation. While the amount of exposed soil associated with features that continued to deliver is relatively small (24.2 m^2/ha.), the harvest erosion features are still delivering sediment over two years after the harvest was completed. Stream bank sloughing was continuing where yarding and tree falling within the stream channel (feature 11) disturbed upper and lower stream banks for several meters. The stream was re-working through slash and fine sediment deposited over the gravel substrate, and was observed to be downcutting and bank cutting in places.

(Note: two erosion features associated with temporary culvert installations were documented and measured during the survey, but are excluded from the sediment routing summary which is focused on harvest-related erosion features. Information on these road crossing features is considered in the road evaluation at the same study site.)

BMP EFFECTIVENESS RATING:

Cable Yarding (Partial Cut Harvest) without Stream Buffers: NOT EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Fishlake Mine: E-01
Treatment Survey ID#: CS-02 Water Type:4
Control Survey ID#: none (see explanation in narrative)

BMP(s) Evaluated: Partial Cut Harvest (cable yarding without stream buffers).
New Road Construction (temporary stream crossing, cut/fillslope construction).

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	57	8/10/92		
Post-Treatment Survey #1:	48	10/22/93	(No site-specific Control Reach available for Fishlake Mine)	
Change from Pre-Treatment Score:	-9			
Net Change (Control-Treatment):	n/a			
Post-Treatment Survey #2:	34	8/16/94		
Change from Pre-Treatment Score:	-23			
Net Change (Control-Treatment):	n/a			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE (for harvest practices)
INDETERMINATE (for road construction practices)

Case Narrative:

The channel condition survey results are rated "indeterminate" for evaluation of road effects because the upstream-downstream comparison intended for this evaluation (with the CS-01 survey reach located upstream of the road crossing intended to serve as the control reach for this survey) was invalidated by interfering effects from harvest activities affecting both study reaches. Preliminary surveys were conducted concurrent with road construction and a year before the completion of timber harvest, but timber harvest in the area of both study reaches occurred before follow-up surveys could be conducted. Road effects noted included in-stream deposition of the gravel-sized material from the temporary road fill at the crossing, which could be distinguished from harvest-related sediment deposition, and some channel downcutting that occurred just downstream of the outflow of the temporary culvert. The decrease in the treatment reach score over the monitoring period is attributable to increases in streambank erosion, fresh sediment deposits, bed mobility/brightness, and slash and cull logs left in the channel causing re-routing of flow into banks. Some destabilization of stairstep (sediment storage) control elements was also noted in specific locations. Comments on the survey forms indicated substantial direct disturbance of stream bed and banks from a cable/skidder yarding route which crossed the stream in the lower portion of the reach. Also noted were cull logs and considerable amounts of slash in the channel; fresh sediment deposition below the road and within the zone of yarding across the stream; bright, angular coarse sediment apparently from the road fill used for the temporary culvert installation above the reach; a drying of in-channel mosses; and channel incision (a new knick point forming just below the temporary culvert site). During the pre-treatment survey it was noted that there was no evidence of previous timber harvest activities in the immediate vicinity of the study reaches, and sediment wedges appeared very stable and were controlled by relatively large, natural wood. The overall morphology and substrate character reach is indicative of a moderate potential to store sediment deposits, particularly medium gravel and larger sizes (such as used in the road fill). Stream banks are moderately susceptible to physical disturbance. The introduction of fresh sediment to the treatment reach is attributable to the crossing of the stream by yarding (primarily fines) as well as the road crossing (primarily gravels). However, the effects of timber harvest activities tend to overwhelm the site-specific effects of sediment from road fill erosion. Physical disturbance of the stream bed and banks is attributable to yarding across the stream and slash/cull log deposits.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Fishlake Mine E-01

Treatment Survey ID#: CS-01 Water Type:4
Control Survey ID#: none Water Type:

BMP(s) Evaluated: Partial Cut Harvest (cable yarding without stream buffers).

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	51	8/11/92		
Post-Treatment Survey #1:	38	10/22/93	(No site-specific Control Reach available for Fishlake Mine)	
Change from Pre-Treatment Score:	-13			
Net Change (Control-Treatment):	n/a			
Post-Treatment Survey #2:	29	8/16/94		
Change from Pre-Treatment Score:	-22			
Net Change (Control-Treatment):	n/a			

BMP EFFECTIVENESS CALL: NOT EFFECTIVE

Case Narrative:

This study reach is located immediately upstream of a the new road where the temporary culvert was placed, and is upstream of the CS-02 reach. The decrease in the treatment reach score is attributable to increases in streambank erosion, fresh sediment deposits, bed mobility/brightness, and slash in the channel causing re-routing of flow into banks. Destabilization of sediment storage elements was also noted. Comments on the survey forms indicated substantial direct disturbance of stream bed and banks (including upper banks) from a cable yarding route which crossed the stream diagonally in the upper portion of the reach. Considerable amounts of slash were left in the channel, resulting in a braided section and flow diversion into banks. During the pre-treatment survey it was noted that there was no evidence of previous timber harvest activities in the immediate vicinity of the study reaches, and sediment wedges appeared very stable and were controlled by relatively large, natural wood. The overall morphology and substrate character reach is indicative of a moderate potential to store sediment deposits, particularly medium gravel and larger sizes. Stream banks are moderately susceptible to physical disturbance. Physical disturbance of the stream bed and banks and in-stream sediment deposition are attributable to yarding within and across the stream and slash/cull log deposits. In the lowermost 6 meters of the reach, extensive fine sediment deposits and severely disturbed stream bed and banks were apparently caused by road construction and yarding of logs to a landing.

In-Stream Photo Point Survey Summary

Site: Fish Lake Mine E-01 Survey dates: 8/11/92, 10/22/93, 8/16/94
Survey Id: PS-01 Treatment Reach (no control comparison)
Water Type: 4 Reach Length: 26 m

Indicators of in-channel changes	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?	X		P1: #12	P1:#2&#3		
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X				
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)? *(Substrate views inadequate in 94/95 due to slash in channel.)		X*				
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X			P1: #3		
5. Are there changes in woody debris?						
Increase in large WD?	X			P2:#5		
Increase in small WD	X			P2:#5/P3:#6		
Decrease in WD?		X*	P3: #14	P3: #6	P3: #20	
*(Some old LWD still present but moved around by yarding.)						
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance? *(Disturbance of bank vegetation; some revegetation evident in 1994.)	X*			P1: #2		

Summary:

This survey was used in conjunction with a Channel Condition Survey to evaluate instream effects of partial cut cable yarding with no buffer on the type 4 intermittent stream (mapped as a type 5 but meets physical criteria for type 4). In the vicinity of P1 there is bank erosion on the lower banks caused by direct disturbance from yarding across the stream. Some upper bank disturbance noted as well. Some bank vegetation came back in 1994. A substantial increase in woody debris within and over the channel was documented, including both large and small diameter logging slash, causing some re-routing of flow onto the low profile stream banks. A cable yarding corridor passed through/across the channel between point P2 and P3. In general, 1994 photos had excessive shadows and brightness, obscuring some details.

BMP Effectiveness Rating: Not Effective

In-Stream Photo Point Survey Summary

Site: Fish Lake Mine E-01 Survey dates: 8/11/92, 10/22/93, 8/16/94
Survey Id: PS-02 Treatment Reach (no control comparison)
Water Type: 4 Reach Length: 40 m

Indicators of in-channel changes	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?	X		P4-P5, #9 P2, #6	P4-P5, #20 P2, #13	P4-P5, #5 & #8 P2, #22	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X				
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X				
4. Is there evidence of increased deposition or storage of fine or coarse sediment?	X		P3-P4, #8 P4-P5, #9	P3-P4, #19 P4-P5, #20	P4-P5, #5 & #8	
5. Are there changes in woody debris?						
Increase in large WD?	X		P4, #8	P4, #19	P4, #4	
Increase in small WD	X		PP, #5	PP, #10	P5, #6	
Decrease in WD?		X	P1, #3&#4 P5, #10	P1, #11 P5, #21		
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?		X				

Summary:

There is evidence of fresh sediment deposits in the reach (both coarse and fine), particularly fine sediment at the yarding crossing upstream of P5. Also, between P4 and P5 there is considerable bank erosion on the lower banks caused by direct disturbance from yarding across the stream, as well as slight increases in bank erosion by flowing water at P2 and P3. Most of the upper bank vegetation came back in 1994. An increase in woody debris was noted, with large diameter cull logs left in the channel near P4, causing some re-routing of flow. Substantial amounts of logging slash were left in the channel near P1 and downstream of P5. In general, 1994 photos had excessive shadows and brightness, obscuring some details. The before after comparison leads to a "Not Effective" rating for harvest practices. This survey reach is located downstream of the temporary road crossing. Photo point survey results are rated "Indeterminate" for evaluation of road effects because the upstream-downstream (PS-01/PS-02) comparison intended for this evaluation was invalidated by interfering effects from harvest activities affecting both study reaches. Preliminary surveys were conducted concurrent with road construction and a year before the completion of timber harvest, but timber harvest in the area of the study reaches occurred before follow-up surveys could be conducted. However, in-stream deposition of the gravel-sized material from the temporary road fill at the crossing could be distinguished from other, harvest-related sediment deposition.

BMP Effectiveness Rating: Not Effective (for harvest practices); Indeterminate (for road construction practices)

Road BMP Effectiveness Summary

Study Site: E-01: Fish Lake Mine - New Road Construction

BMP Effectiveness Ratings

	Survey Employed	Culvert BMPs: Stream Xings (WAC 222-24-040)	Culvert BMPs: Relief (WAC 222-24-025)	Road Construction BMPs (WAC 222-24-030): Cutslopes	Road Construction BMPs (WAC 222-24-030): Fillslopes
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Cutbank/Fillslope: CF-01	Not Effective		Effective	Effective

Case Narrative: The stream crossing evaluated in CF-01 road segment was a temporary culvert installation, with large logs placed alongside and above the culvert, and below a fabric layer, and gravel-sized road fill material placed above the fabric layer. Between the preliminary and follow-up surveys, the road fill, culvert, and logs were removed from the stream channel, with the road fill sloped back on both sides of the stream. Attempts to stabilize the road fill and disturbed areas of the stream valley by dry grass seeding were unsuccessful, and chronic sediment delivery was observed at two such temporary crossings of the same stream. At the lower crossing site within the CF-01 survey segment, there was sediment delivery from a disturbed area of 65 m^2 that was still over 75% exposed over 18 months following removal of the temporary culvert. At an upper crossing site, there was sediment delivery from a disturbed area of 426 m^2 that was still over 75% exposed over 18 months following removal of the temporary culvert. Cutslope BMPs were rated effective in spite of chronic erosion on large, highly exposed road cuts, because there was no evidence of delivery of the eroded material to the stream crossing. On one side of the crossing the road was crowned or outsloped with no ditch, while on the other side there was no evidence of sediment transport via surface flow in the ditch. Fillslope BMPs were rated effective because, although continuing to erode, fill material delivered only in the immediate vicinity of the stream crossing.

	Survey Employed	Stream Xings	Relief	Cutslopes	Fillslopes
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-02/CS-01	Indeterminate		Indeterminate	Indeterminate
	Photo Point: PS-02/PS-01	Indeterminate		Indeterminate	Indeterminate

Case Narrative: The channel condition and photo point survey results are rated "indeterminate" for evaluation of road effects because the upstream-downstream comparison intended for this evaluation was invalidated by interfering effects from harvest activities affecting both study reaches. Preliminary surveys were conducted concurrent with road construction and a year before the completion of timber harvest, but timber harvest in the area of the study reaches occurred before follow-up surveys could be conducted. However, in-stream deposition of the gravel-sized material from the temporary road fill at the crossing could be distinguished from other, harvest-related sediment deposition. It was also noted during follow-up surveys that channel incision was occurring just downstream of the outflow of the temporary culvert. At an upper temporary road crossing site, in-stream deposition of eroded road fill material was observed to extend at least 15 meters downstream of the crossing.

		Stream Xings	Relief	Cutslopes	Fillslopes
OVERALL SITE BMP EFFECTIVENESS RATING:		NOT EFFECTIVE		EFFECTIVE	EFFECTIVE

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Fish Lake Mine Road		
Survey Id #'s	CF-01		
Survey Dates	10/22/93 & 8/16/94, with follow-up observations in October 1995		
Water Type	4		
Road Construction Date:	8/92		
Length of Road		Range Road Gradient	4-15 %
Draining to Stream	79 meters	Average Road Gradient	9 %
		Range Hillslope Gradient	29-47 %
		Average Hillslope Gradient	37 %
		Range Cutslope Gradient	14-45 deg.
		Average Cutslope Gradient	32 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	50		33	
% Observations w/med. slope height	50		67	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	0	0	33
% Observations w/26-50 % exposed soils	50	50	0	0
% Observations w/51-75 % exposed soils	0	0	67	33
% Observations w/76-100 % exposed soils	50	50	33	33
% Observations w/Evidence of Erosion	66	100	66	100
Evidence of Erosion w/delivery to surface water	no	no	Only at temporary crossing site	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	yes	no	yes
BMP Effectiveness Ratings:	**Effective**		**Effective**	
	Temporary Stream Crossing:		**Not Effective**	

COMMENTS:

The forest practices evaluated with this survey included road construction practices for cut and fill slopes, and a temporary crossing of a type 4 stream that is within the road drainage segment. The stream crossing was designed to be a temporary structure, and was removed between the 1993 and 1994 surveys, following timber harvest at the site. Whole logs were placed parallel to the culvert and covered with a fabric layer, which was then covered with native roadfill material composed of crushed serpentine. Upon completion of the harvest, the temporary crossing structure was removed, and the fill material excavated from the stream bed and sloped back and piled on the road grade adjacent to the stream. An unsuccessful attempt was made to stabilize these materials by grass seeding. The primary mechanism of sediment delivery from this road segment to the stream was via erosion of the materials piled adjacent to the channel following removal of the temporary crossing. A follow-up inspection of the crossing site in October 1995 confirmed that there was chronic sediment delivery from a disturbed area of 65 m^2,that was still over 75% exposed over 18 months following removal of the temporary culvert. At an upper crossing site on the same stream (not included in the CF-01 drainage segment), there was sediment delivery from a disturbed area of 426 m^2, that was still over 75% exposed over 18 months following removal of a temporary culvert crossing. In-stream deposition of eroded road fill material was observed downstream of both crossing sites. Cutslope BMPs are rated effective in spite of chronic erosion on large, highly exposed road cuts, because there was no evidence of delivery of the eroded material to the stream crossing. On one side of the crossing the road was crowned or outsloped with no ditch, while on the other side there was no evidence of sediment transport via surface flow in the ditch. Fillslope BMPs were rated effective because, although continuing to erode, fill material delivered only in the immediate vicinity of the stream crossing. A water bar resulted in a gully across the fillslope that extended 21 meters but did not deliver to the stream.

Site E-02: Plesha Road

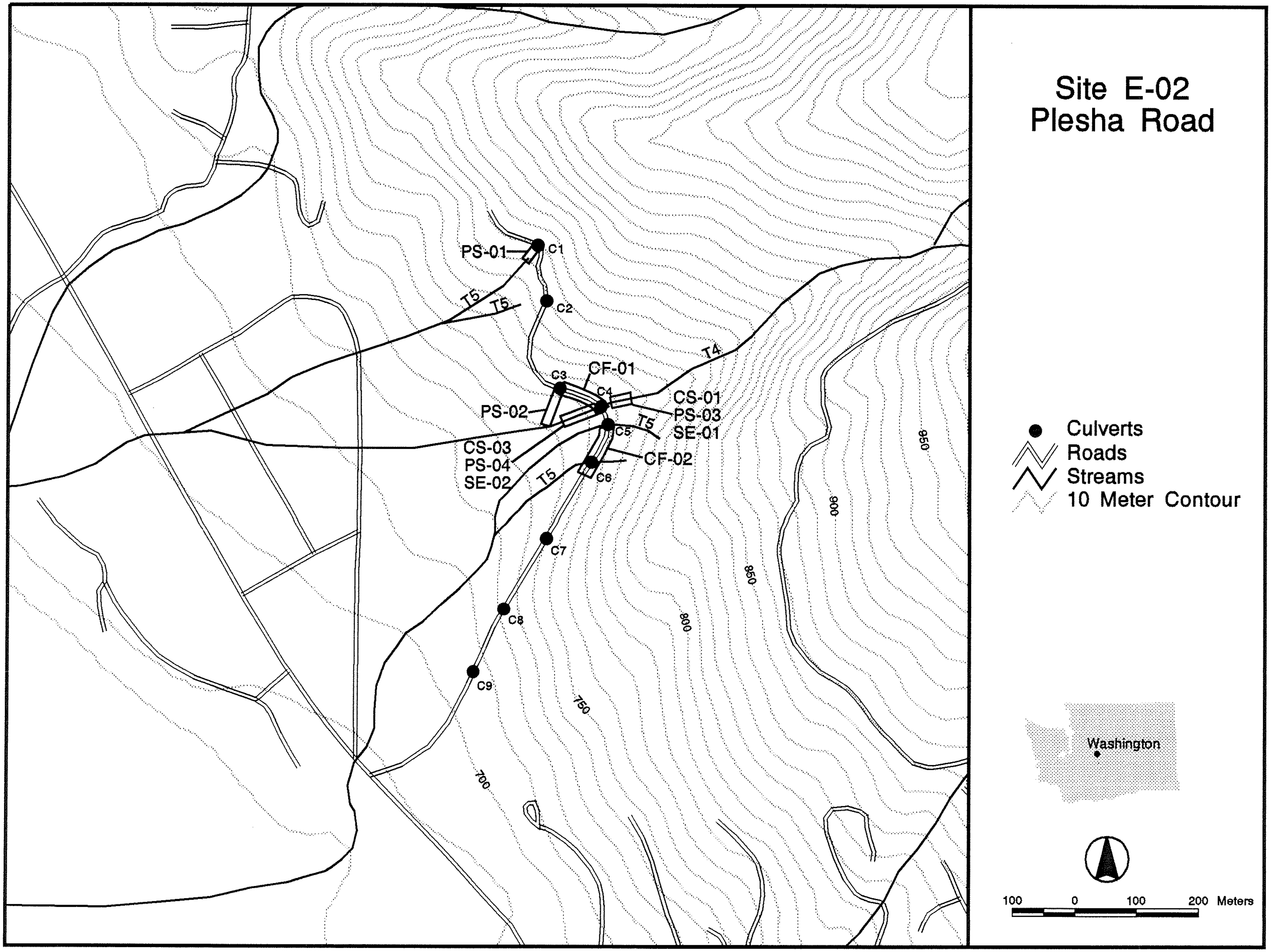
Plesha Road is a new road construction site located in west-central Kittitas County in the Eastern Cascades physiographic region. The surface geology of the site is mapped as feldspathic sandstone of the Roslyn Formation. Soils at the study site are mapped as Nard loam and Nard silt loam, 25-45% slopes. These soils are rated as stable for disturbed slope stability, with a moderate cutbank/fill/sidecast hazard and a medium erosion potential. Based on stream valley side slope gradients of 12-46% measured at the main Type 4 stream crossing, the road construction BMP slope hazard category for the site is moderate. At other locations surveyed along the road alignment, hillslope gradients ranged from 23-54%.

The primary study stream at this site is a zero-order, Type 4 stream that is a tributary to Cle Elum Lake on the Cle Elum river. The downstream study reach on this stream has a step-pool morphology with an average active channel width of 2 meters and an average gradient of 15%. The road also crosses two Type 5 streams and traverses just upslope of two other Type 5 channel heads.

Forest practices conducted at this site over the study period include about 1 kilometer of new road construction, which provided access to a 15 hectare partial cut harvest unit located at the end of the road. Timber harvesting did not occur in the vicinity of the study streams or road surveys. The road construction was completed in July 1992, with additional maintenance and erosion control work conducted in the summer of 1993.

BMPs evaluated at the Plesha Road site were the new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). A treatment reach was established on the Type 4 stream, downstream of the culverted road crossing, with a control reach located upstream of the road on the same stream. Channel condition and photo point surveys were conducted in November 1992, October 1993, and August 1994. Stream bank erosion surveys were conducted on the same study reaches in October 1992 and June 1994. Cutbank/fillslope surveys were conducted within two road drainage segments, one draining to the Type 4 stream crossing and one draining to a Type 5 crossing, in October 1993 and October 1994. An erosion pin network was installed on a portion of the cutslope in the Type 4 drainage segment, but the pins were lost due to cutbank sloughing and/or maintenance activities before follow-up measurements could be made. Culvert condition surveys encompassing 754 meters of the new road construction were conducted in November 1992, October 1993 and October 1994. Photo point surveys and channel profile and cross-section measurements were made in conjunction with the culvert condition survey to evaluate sediment transport and channel head changes downslope of relief culverts.

Site E-02
Plesha Road



Road BMP Effectiveness Summary

Study Site: E-02: Plesha Road - New Road Construction

BMP Effectiveness Ratings

	Survey Employed	Culvert BMPs: Stream Xings (WAC 222-24-040)	Culvert BMPs: Relief (WAC 222-24-025)	Road Construction BMPs: Cutslopes (WAC 222-24-030)	Road Construction BMPs: Fillslopes (WAC 222-24-030)
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition:				
	CC-01	Not Effective	Effective		
	Cutbank/Fillslope:				
	CF-01			Not Effective	Effective
	CF-02			Effective	Effective
	Photo Point:				
	PS-01 & PS-02		Effective		
	Erosion Pin Network:				
	EP-01			Indeterminate	

Case Narrative: Relief culverts did not deliver to streams over the 27 month post-construction monitoring period and are rated effective. Sediment transport distances downslope of relief outfalls ranged from less than 1 meter to 27 meters. Several of the relief culverts had functioning sediment traps. Maintenance/clean-out of ditches and sediment traps was noted in the 1993 culvert condition survey. Photo point surveys and channel profile and cross-section measurements made to evaluate effects of road drainage on a stream channel head just downslope of culvert C1 did not detect headward migration or other channel changes over the monitoring period. Erosion of culvert fills at stream crossings was continuing at moderate to severe levels 27 months following road construction, despite re-armoring of some culvert fills in 1993. Cutslope erosion continued at moderate to severe levels due to the highly erodible soils and a lack of adequate revegetation practices, resulting in chronic sediment delivery via sediment transport in the ditch draining to the type 4 stream crossing (CF-01 drainage segment). An erosion pin network installed to monitor cutslope erosion in the same drainage segment was rated indeterminate because the pins were lost as a result of sloughing of the road cut and/or ditch maintenance activities before follow-up measurements could be made. BMPs at another cutslope in the CF-02 drainage segment were rated effective because there was no evidence that eroded cutslope material was delivered to the type 5 stream. There was little evidence of surface flow in the ditch at this relatively flat drainage segment, and a small sediment trap appeared to have prevented sediment delivery to the stream. The fillslopes were not found to deliver sediment except at the immediate vicinity of culverts fills (with exception of minor amounts of ravel from the CF-02 segment), and are rated effective.

	Survey Employed	Stream Xings	Relief	Cutslopes	Fillslopes
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:				
	CS-03/CS-01	Effective		Effective	Effective
	Photo Point:				
	PS-04/PS-03	Effective		Effective	Effective
	Stream Bank Erosion:				
	SE-02/SE-01	Effective		Effective	Effective

Case Narrative: The channel condition surveys reflect increases in fresh sediment deposits and streambed mobility in the treatment reach downstream of the road crossing, as compared to the upstream control reach. Although the treatment reach channel condition score decreased by 19% over the monitoring period, the net decrease in score was less than the 10 point threshold, leading to an effective rating. In-stream photo point surveys showed very little change over the monitoring period. Stream bank erosion surveys documented increased bank erosion in both treatment and control reaches, with greater increases observed in the control reach. Stream banks in both study reaches were composed of highly erodible weathered sandstone.

	Stream Xings	Relief	Cutslopes	Fillslopes
OVERALL SITE BMP EFFECTIVENESS RATING:	PARTIALLY EFFECTIVE	EFFECTIVE	PARTIALLY EFFECTIVE	EFFECTIVE

Plesha Road Culvert Condition Survey Results

Site: E-02: Plesha Road
Culvert Condition Survey CC-01

Survey dates: 11/3/92, 10/21/93 & 10/26/94
Date of Construction: 7/92

Site BMP Effectiveness Rating:

Stream x-ing: Not effective
Relief: Effective

Culvert # and Type	Point of Observation	Extent of Erosion Year 1992	1993	1994	Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No)
C-1	Inflow	Slight	Slight	Moderate	104 m	Increase	Y	Yes,	No	Yes
Relief	Outflow	Slight	Slight	Severe	(104m)	Increase	Y	7 m overland flow		
C-2	Inflow	Slight	Slight	Severe	96 m	Increase	Y	Yes,	No	Yes
Relief	Outflow	None	Slight	Moderate	(96m)	Increase	Y	10m overland flow		
C-3	Inflow	None	Slight	Severe	125m	Increase	Y	No	No	Yes
Relief	Outflow	None	Slight	Severe	(125m)	Increase	Y			
C-4	Inflow	Slight	Slight	Moderate	56 m	Increase	Y	n/a	Yes	No
Type-4, x-ing	Outflow	Slight	Moderate	Moderate	(65m)	Increase	Y			
C-5	Inflow	None	Slight	Moderate	27 m	Increase	Y	n/a	Yes	No
Type-5,x-ing	Outflow	Moderate	Moderate	Severe	(18m)	Increase	Y			
C-6	Inflow	None	None	Slight	57 m	Increase	Y	n/a	Yes	No
Type-5, x-ing	Outflow	Moderate	Moderate	Severe	(80m)	Increase	Y			
C-7	Inflow	Slight	Moderate	Severe	133m	Increase	Y	Yes,	No	Yes
Relief	Outflow	Slight	Slight	Severe	(110m)	Increase	Y	27m overland flow		
C-8	Inflow	Moderate	slight	Severe	139 m	Increase	Y	Yes	No	Yes
Relief	Outflow	Moderate	Moderate	Moderate	(139m)	Constant	Y	21m , overland flow		
C-9	Inflow	slight	slight	Moderate	110 m	Increase	Y	Yes,	No	Yes
Relief	Outflow	None	Slight	Moderate	(110m)	Increase	Y	5m overland flow		

Plesha Road Culvert Condition Survey Results

Comments/ Notes Summary:

The length of the road surveyed was 754 meters, with an average gradient of 7 % and gradient range of 2-14 %. The average spacing between culverts was 83 meters. The average hillslope gradient was 34 %, with a range of 23-53 %. In addition to the 9 culverts, survey notes were taken on 5 water bars constructed along the road following a timber harvest located at the end of the road. There was no sediment delivery to streams from any water bars over the course of the monitoring period. Relief drainage from WB1, located between C1 and C2, formed a gully on the fillslope below which an overland flow sediment plume extended 15 meters down slope. WB2, between C2 and C3, was noted to not be relieving the ditch, but only diverting drainage from the road surface. WB3, between C6 and C7 was noted to have formed a gully on the fillslope, but no sediment plume was observed down slope of this minor gully. Relief drainage from WB4, between C7 and C8, channelized through the slash berm at the toe of the fillslope, and combined with drainage from C7 to produce an overland flow sediment plume extending 27 meters down slope. Relief drainage from WB5, between C8 and C9, combined with drainage from C8 to produce an overland flow sediment plume extending 21 meters down slope.

The extent of erosion on culvert fills in the 1992 survey was generally low, probably a reflection of the age of the road and the low number of precipitation events which had occurred since the time of construction. Local material, consisting of highly erodible weathered sandstone was used to armor the culvert fills at the time of the 1992 surveys. It was noted in the 1993 survey that the ditches leading to the culverts had been cleaned out and the immediate areas of the culvert inflows armored with erosion resistant materials, primarily cobble-sized rock. Erosion of the culvert fills was documented at all culverts in 1993 and 1994, with delivery occurring at the stream crossings. Dry grass seeding may have been applied, but it was not successful in stabilizing disturbed soils at the site. Erosion of culvert fills at stream crossings was continuing at moderate to severe levels 27 months following road construction, despite re-armoring of some parts of culvert fills in 1993. Relief culverts did not deliver to streams over the 27 month post-construction monitoring period and are rated effective. Sediment transport distances downslope of relief outfalls ranged from less than 1 meter to 27 meters. Relief culvert C3 had a functioning sediment trap and no down slope sediment transport. Photo point surveys and channel profile and cross-section measurements made to evaluate effects of road drainage on a stream channel head just downslope of culvert C1 did not detect headward migration or other channel changes over the monitoring period.

During the 1994 survey, two days of hard rain resulted in a run-off event that allowed the investigators to observe the active erosion processes while conducting the survey. Several relevant observations were made: 1) two years after construction, revegetation of exposed soils within the road prism was sparse and patchy--some areas of the fillslope and ditch were vegetated while most of the cutslope remained exposed and eroding; 2) sediment traps constructed at some relief culvert inflows were effectively capturing non-colloidal particles transported in the ditches, 3) sediment was being transported via overland flow through those relief culverts lacking sediment traps, or, in one instance, where the trap had become full and was no longer functioning; 4) despite overland flow of sediment, none of the relief culverts or water bars delivered to surface waters; 5) the slash berms left at the toe of the fillslope during road construction was only partially effective at storing sediment transported through relief culverts. Relief drainage from C7 and C8 developed sediment plumes extending beyond slash piles; and 5) during this runoff event, only the relief culverts had flowing water at their inflows and outflows. Of the three stream crossings, only C5 had a trickle flow.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Plesha Road
Survey Id #'s	CF-01
Survey Dates	10/21/93 & 10/26/94, with follow-up observations in 9/95
Water Type	4
Road Construction Date:	7/92
Length of Road Draining to Stream	66 meters

Range Road Gradient	2-5 %
Average Road Gradient	3.8 %
Range Hillslope Gradient	23-30 %
Average Hillslope Gradient	28%
Range Cutslope Gradient	35-54 deg.
Average Cutslope Gradient	44 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	50		75	
% Observations w/med. slope height	50		25	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	0	0	75
% Observations w/26-50 % exposed soils	25	25	25	25
% Observations w/51-75 % exposed soils	0	25	50	0
% Observations w/76-100 % exposed soils	75	50	25	0
% Observations w/Evidence of Erosion	100	100	100	75
Evidence of Erosion w/delivery to surface water	yes	yes	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	no	no	minor
BMP Effectiveness Rating:	**Not Effective**		**Effective**	

COMMENTS:

In 1993, evidence of erosion for both cutslopes and fillslopes was in the form of minor slumping, minor surface erosion and some rills. Some sediment storage was noted at the toe of the cutslope and in slash on fillslopes. It was noted that sediment stored within the ditches had recently been cleaned out. No seeps were noted in the surveyed segment. Types of erosion observed in 1994 for cutslopes was sheetwash erosion (leaving residual soil pedestals) and minor sloughing. Fillslopes were observed to have minor gullying, tension cracks, and surface erosion. Sediment was stored at the toe of the cutslopes and in the slash on fillslopes. Re-vegetation occurred by natural means; dry grass seeding may have been applied but it had little effect. Fillslopes showed more vigorous re-vegetation growth than the cutslopes. The 1994 survey was conducted during heavy periods of rain. Water was observed flowing in the ditches with some of it appearing slightly turbid in the photos. The delivery noted for fillslopes was limited to the fill at the culvert location. During a follow-up site inspection in September 1995, following a runoff event, fresh sediment deposits were observed at the culvert inflow as well as downstream of the culvert, indicating continued delivery of eroded cutslope and road surface material via the ditch. Cutslopes were still mostly bare in 1995, over three years following road construction.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Plesha Road
Survey Id #'s	CF-02
Survey Dates	10/21/93 & 10/27/94, with follow-up observations in 9/95
Water Type	T-5
Road construction date	7/92
Length Road Draining to Stream	80 meters

Range Road Gradient	1-4 %
Average Road Gradient	2.5 %
Range Hillslope Gradient	23-54 %
Average Hillslope Gradient	39%
Range Cutslope Gradient	28-48 deg.
Average Cutslope Gradient	41 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	50		50	
% Observations w/med. slope height	25		25	
% Observations w/high slope height	25		25	
	1993	1994	1993	1994
% Observations w/0-25% exposed soils	0	0	0	0
% Observations w/26-50 % exposed soils	0	0	0	50
% Observations w/51-75 % exposed soils	25	25	50	0
% Observations w/76-100 % exposed soils	75	75	50	50
% Observations w/Evidence of Erosion	100	100	75	100
Evidence of Erosion w/delivery to surface water	no	no	Only at culvert fill	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	minor	no	minor
BMP Effectiveness Rating:	**Effective**		**Effective**	

COMMENTS:

In 1993, erosion on both the cutslopes and fillslopes was by minor sloughing, minor ravel, and minor surface erosion. Sediment eroded from cutslopes was stored in the ditch, and that for fillslopes was stored in the slash berm at the toe of the fillslope, with some sidecast material noted as having raveled into the type 5 stream channel up to 4 meters downstream of the culvert. In the 1994 survey, erosion observed on the cutslopes was minor slumping, and surface erosion. The fillslopes were noted as having minor gullying and substantial surface erosion. Sediment storage was observed at the toe of the cutslope, in the ditch, and the slash berm at the toe of the fillslope. During a follow-up site inspection in September 1995, gravel-sized sediment deposits were observed in the type 5 stream, extending about 12 meters downstream of the culvert. This in-stream deposition, with an estimated volume of 1 m^3 was attributed to erosion of the culvert fill plus sidecast ravel from the fillslope adjacent to the culvert. Observations made during field surveys and the 1995 site visit, which followed a runoff event, indicate that this culvert (C-6) only rarely carried surface flow. The 1994 CF-02 survey was conducted during heavy rains. Standing turbid water was observed in some ditch sections along the road, but no stream flow was observed at the inflow or outflow of the culvert in the CF-02 drainage segment. In addition, there was very little residual evidence of surface flow in the ditch below the cutslope in this relatively flat drainage segment, even during or immediately after runoff events. Apparently, the lack of surface runoff in the ditch and the small sediment trap constructed at the culvert inflow prevented delivery of sediment eroded from the cutslope and road surface to the stream.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Plesha Road

Treatment Survey ID#:	CS-03	Water Type:	4
Control Survey ID#:	CS-01	Water Type:	4

BMP(s) Evaluated: New Road Construction (stream crossing, cut and fillslope construction).

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Preliminary Surveys:	31	11/5/92	47	11/4/92
Post-Treatment Survey #1:	39	10/21/93	47	10/21/93
Change from Pre-Treatment Score:	+8		0	
Net Change (Control-Treatment):	+8			
Post-Treatment Survey #2:	25	8/16/94	49	8/16/94
Change from Pre-Treatment Score:	-6		+2	
Net Change (Control-Treatment):	-8			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
The preliminary surveys were conducted 3-4 months following road construction. Any in-stream effects from the road construction at that time were very limited (some sediment deposition immediately below the culvert outfall.) The decrease in treatment reach score is attributable primarily to an increase in fresh sediment deposits and increased bed mobility/brightness. This would appear to reflect sediment delivered via the road fill and cutslopes/ditches. The morphology of the reach is such that portions of it readily accumulate fine sediments, and fines (sand-sized) were noted as the dominant particle size. In addition, certain sediment storage elements were rated as being less stable in the treatment reach, although they are recognized as being fragile throughout this stream, due in part to the soft, crumbly nature of the weathered sandstone bedrock. The net change in score is less than 10 points, leading to an "effective" call for this survey.

Stream Bank Erosion Survey

Stream Bank Erosion Survey

Site:	Plesha Road	Treatment		
Survey Dates:	11/92 & 6/94	Water Type: 4		
Survey #:	SE-02	Total reach length center line: 57.0M		
		Length of left bank: 56.8M		
		Length of right bank: 54.5M		
		Total Bank length: 111.3M		
		Year		
		1992	1993	1994
Total # eroding banks		11		9
Total # Sampled		11		9
Total length of eroding banks		38.6M		45.8M
Total area of eroding banks		38.7M sq.		45.3M sq.
% of bank length eroding:		35%		41%
Cause of Bank Erosion:		Length of Eroding Banks:		
Flowing Water		38.6M		45.8M

Stream Bank Erosion Survey

Site:	Plesha Road	Control		
Survey Dates:	11/92 & 6/94	Water Type: 4		
Survey #:	SE-01	Total reach length center line: 32.0M		
		Length of left bank:35.4M		
		Length of right bank:35.1M		
		Total bank length:76.5M		
		Year		
		1992	1993	1994
Total # eroding banks		10		11
Total # Sampled		10		11
Total length of eroding banks		20.7M		30.2M
Total area of eroding banks		11.0M sq.		24.9M sq.
% of bank length eroding		27%		40%
Cause of Bank Erosion:		Length of Eroding Banks:		
Flowing water		20.7M		30.2M

Forest practices evaluated at this site are new road construction in the vicinity of a Type-4 stream crossing. In the preliminary surveys conducted in 1992 just after road construction, it was observed that the stream channel had incised through highly erodible, sandy soils and weathered sandstone bedrock. Both control and treatment reaches had bank disturbance due to scour and sloughing attributable to the effects of flowing water. The control reach upstream of the road crossing had a greater increase in the extent of eroding banks over the monitoring period than did the treatment reach. There was no evidence of adverse effects from the road drainage or road construction. Heavy snowfall and leaf litter on the day of the 1993 surveys prevented the investigators from measuring the banks accurately.

BMP Effectiveness Rating: EFFECTIVE

In-Stream Photo-Point Survey Comparison Summary

Site: Plesha Road E-02 Survey Dates: 11/92, 10/93, & 8/94

Study Reach Descriptions: Treatment reach is 55 meters downstream of road crossing (culvert C4); control reach is 41 meters upstream of crossing on same stream.

Indicators of in-channel changes		Control PS-03 Yes	Control PS-03 No	Treatment PS-04 Yes	Treatment PS-04 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?			X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?			X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?			X		X
4. Is there evidence of increased deposition or storage of fine or coarse sediment?			X	X	
5. Are there changes in woody debris? (indicate numbers of windthrown trees documented over the survey period)	Increase in large WD?		X		X
	Increase in small WD?	X			X
	Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?			X		X

Summary:

Very little change was apparent in either study reach over the monitoring period, based on year-to-year comparison of the photos. Minor changes included one new piece of SWD in control, and one sediment deposit in treatment, but in this case this was un-related to the road (a fragile sandstone boulder rolled down and crumbled in the channel). Some photo point comparisons showed virtually no change over the two years; numerous small pieces of wood (small branches and twigs) had remained in position, indicating minimal surface flow in this stream over the monitoring period.

BMP Effectiveness Rating: Effective

Site E-04: Green Canyon

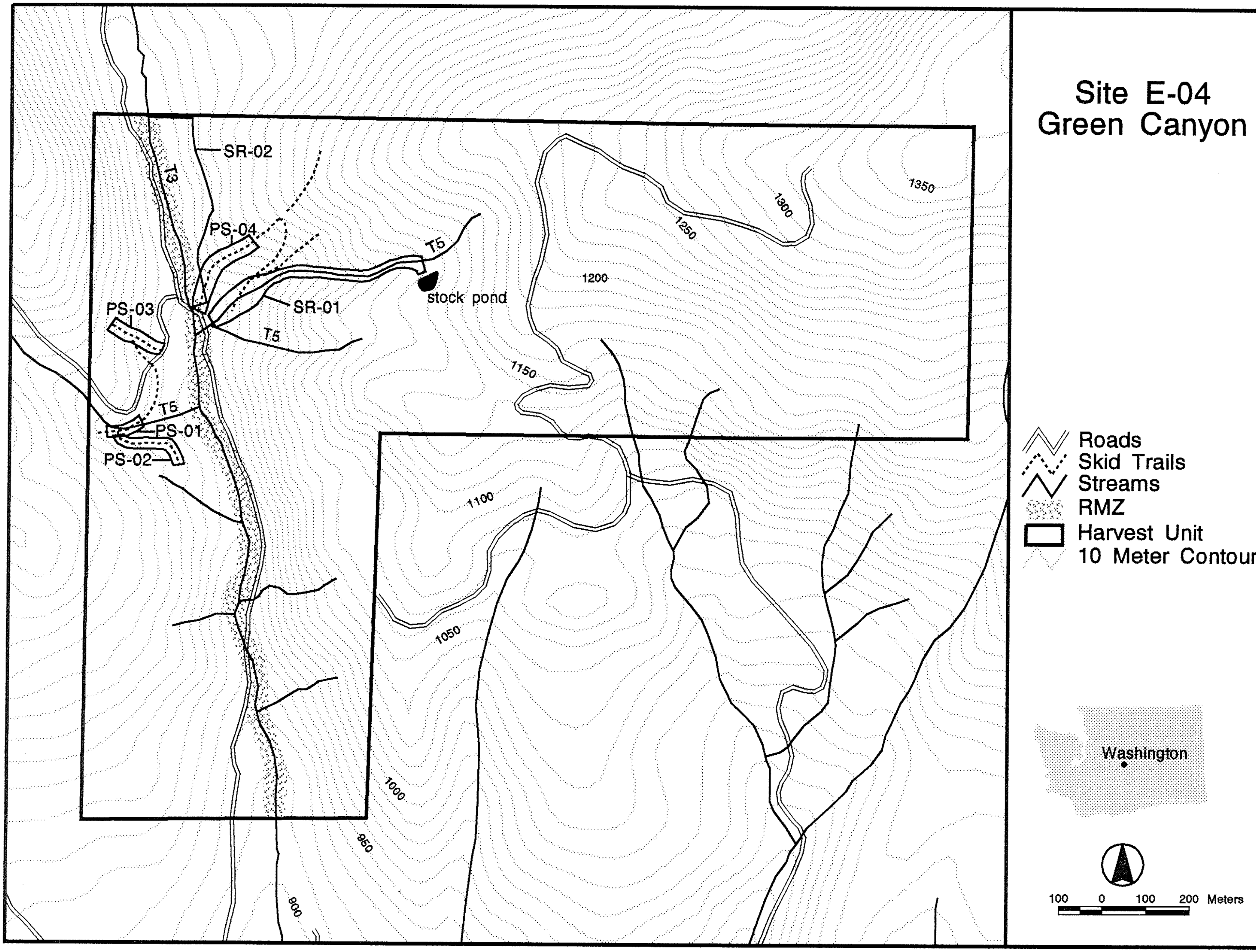
The Green Canyon site is a harvest practice evaluation located in northeast Kittitas County in the Eastern Cascades physiographic region. The surface geology of the area is mapped as the margin of the Columbia Plateau basalt flows. Soils at the site are varied, but the most common soil type is Loneridge stony loam, 25-45% slopes. These soils are rated as stable for disturbed slope stability with a moderate cutbank/fill/sidecast hazard, and medium erosion potential. Based on stream valley side slopes, which ranged from 18-66% in the vicinity of survey areas, the harvest BMP slope hazard category for the site is high.

Study streams within the harvest unit include a 1st order, Type 3 stream, and two zero-order Type 5 streams. The Type 5 streams are tributaries of the Type 3 stream, which is a tributary of Reecer Creek in the Yakima River basin.

Forest practices conducted at this site include a 162 hectare partial cut harvest using ground-based yarding methods (tracked and/or wheeled skidders), with a RMZ established along the Type 3 stream. The average width of the RMZ in the vicinity of survey areas was 16 meters. Harvest in vicinity of the survey areas was completed by November 1992.

BMPs evaluated at the site included the RMZ on the Type 3 stream with adjacent ground-based harvesting, and ground-based harvesting in the vicinity of Type 5 streams without stream buffers. Photo point surveys evaluating skid trail erosion and sediment delivery were conducted in November 1992 and April 1994. Two sediment routing surveys were conducted in April 1994 along one of the Type 5 streams and along a portion of the RMZ.

Site E-04
Green Canyon



Harvest BMP Effectiveness Summary

Study Site: E-04: Green Canyon - Partial cut harvest, with RMZ and harvest without stream buffers

BMP Effectiveness Ratings

	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050): Ground-based Yarding WAC 222-30-070	Harvest w/ RMZ & Streambank Integrity BMPs: Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters): Ground-based Yarding WAC 222-30-070	Harvest with no buffers (Type 4 and/or 5 Waters): Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)): Ground-based Yarding WAC 222-30-070	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)): Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01			Partially Effective			
	SR-02	Effective					
	Photo Point (Skid Trails):						
	PS-01			Partially Effective			
	PS-02			Effective			
	PS-03	Effective					
	PS-04	Effective					
Case Narrative:	The RMZ was effective at preventing sediment delivery directly to the type 3 stream from erosion associated with harvest activities. In the vicinity of the survey areas, there was no timber harvest within the RMZ, which was sparsely vegetated due to historical grazing and land clearing activities. The SR-02 sediment routing survey, conducted 17 months following timber harvest, documented sediment delivery to the type 3 stream from erosion caused by wildlife activity (*e.g.* , elk trails) and stream bank erosion, but not from skid trails. Photo point surveys evaluating skid trail erosion in the vicinity of the RMZ found that water bars constructed on the skid trails were effective at preventing gullies or other chronic erosion problems and storing or diverting sediment, so that no delivery to the type 3 stream was observed, even though one of the skid trails came within about 4 meters of the stream. Localized sediment delivery to an unbuffered Type 5 stream was documented at a skid trail crossing in the SR-01 survey. The trail crossing was made at a location on this intermittent stream where there was no defined channel, and there was no evidence of substantial amounts of sediment delivery beyond the immediate crossing area. However, the skid trial was not water-barred or revegetated, and potential exists for chronic sediment delivery to the stream system during snowmelt or runoff events. Photo point surveys evaluating skid trail erosion in the vicinity of another unbuffered type 5 stream found that water bars constructed on one of the skid trails were effective at preventing gullies or other chronic erosion problems, and storing or diverting sediment, thus preventing delivery to the stream located downslope of the trail. The PS-01 survey evaluated another skid trail that was located within a type 5 drainage swale that had intermittent flow in a discontinuous, ill-defined channel. There was localized disturbance and sediment routing within the drainage, but no evidence that sediment was routed downstream of the skid trail.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Photo Point:						
	PS-01			Partially Effective			
Case Narrative:	As noted above, the PS-01 survey found localized in-stream effects within a type 5 stream drainage that was used as a skid trial route. Effects were limited due to the intermittent nature of surface flow and lack of a well-defined stream channel, and there was no evidence of sediment routing downstream of the point where the skid trail veered out of the drainage swale.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE		PARTIALLY EFFECTIVE			

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Green Canyon	Survey Date	4/26/94
Site Id #	E-04	Survey Id #	SR-01
Water Type	5	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	stock pond berm	yes	120.0	not recorded	n/a
2	skid trail	no	3.9	not recorded	n/a
3	wildlife	no	1.0	not recorded	n/a
4	wildlife	no	3.0	not recorded	n/a
5	wildlife	yes	21.0	not recorded	n/a
6	yarding	no	5.1	not recorded	n/a
7	yarding	no	23.4	not recorded	n/a
8	skid trail	no	65.6	not recorded	n/a
9	skid trail	no	413.4	not recorded	n/a
10	skid trail	yes	302.1	25-50	113.3
11	skid trail	no	129.6	not recorded	n/a
	TOTALS	3 delivered	1088.1		

Total Area of Ground Surveyed = 1.6 hectares

Total Length of Stream Bank surveyed = 851 meters

Disturbed Soil per hectare = 680.1 m^2/hectare

Area Exposed Soil per Hectare = Not Determined

***Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 113.3 m^2**

***Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 70.6 m^2/hectare**

*Features that delivered but were not directly attributable to current harvest practices, such as windthrow, wildlife activity, etc., were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of **Disturbed** Soil	**Disturbed** Soil from Features which Delivered (m^2)	% of Total Delivery (based on area of **Disturbed** Soil
Stock Pond Berm	1	120.0	120.0	27.1
Wildlife	3	25.0	21.0	4.7
Skid Trail	5	914.6	302.1	68.2
Yarding	2	28.5	0.0	0.0

NARRATIVE:

The forest practices evaluated with this survey were partial cut harvesting using ground-based equipment along a zero-order type 5 stream that was not buffered. For most of its length the stream had a defined channel, but it was not continuous, with intermittent surface flow at the time of the survey. In the lower part of the valley the type 5 became a swale without a defined channel. A road crossed the lowermost part of the swale and a landing were located on a wide, flat area where the swale joined the floodplain of the type 3 tributary to Reecer Creek. Subsurface flow through this portion of the swale was indicated by a concentrated surface discharge to the type 3 stream, which surfaced just beyond the road. The only erosion feature identified in the survey that was directly related to harvest operations and that delivered sediment to the stream system was a skid trail (feature #10) located within 10 meters of the type 5 stream. The lower portion of the skid trail crossed the swale at a point where there was no channel. Sediment delivery appeared localized, apparently due to a lack of surface flow in this part of the type 5. However, during snowmelt episodes and other times of surface runoff, the bare soils of this skid trail (which was not water-barred or grass-seeded) may be a chronic source of sediment to the stream system. Although the survey documented continued sediment delivery from the skid trail up to 17 months following harvest, there was not evidence of significant amounts of sediment routing beyond the immediate area of the crossing during the study period, so the practice is considered partially effective. (The degree of soil exposure was not determined for features 1-9 and 11, which did not deliver sediment to the stream and/or were not related to timber harvest operations.)

BMP EFFECTIVENESS RATING:

Ground-based Yarding (Partial Cut Harvest) without Stream Buffers: PARTIALLY EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Green Canyon	Survey Date	4/26/94
Site Id #	E-04	Survey Id #	SR-02
Water Type	3	Months Since Harvest	17

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	sediment deposit	no	(surface area: 5.1 m^2)	n/a	n/a
2	skid trail	no	113.9	not recorded	n/a
3	bank erosion	yes	20.0	not recorded	n/a
4	wildlife	yes	27.3	not recorded	n/a
	TOTALS	2 delivered	161.2		

Total Area of Ground Surveyed = 0.4 hectares

Total Length of Stream Bank Surveyed = 168 meters

Disturbed Soil per Hectare = 403.0 m^2/hectare

Exposed Soil Area per Hectare = Not Determined

***Surface Area Disturbed/Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2**

***Disturbed/Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/hectare**

*Features that delivered but were not directly attributable to current harvest practices, such as windthrow, wildlife activity, etc., were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of **Disturbed** Soil (m^2)	**Disturbed** Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of **Disturbed** Soil)
skid trail	1	113.9	0.0	0
wildlife	1	27.3	27.3	57.7
bank erosion	1	20.0	20.0	42.3

NARRATIVE:
The forest practices evaluated with this survey were partial-cut harvesting using ground-based yarding along a type 3 stream buffered with an RMZ. The RMZ, which was not yarded across, was effective at preventing direct sediment delivery from harvest site erosion, even though the skid trail feature came to within several meters of the stream. The only erosion features that delivered to the stream were not related to current harvest operations: stream bank erosion caused by flowing water and wildlife activity on the hillslope. The degree of soil exposure was not determined in this field survey.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

Skid Trail Photo Point Survey Summary

Site: Green Canyon (E-04) Survey dates: 11/6/92 & 4/25/94
Survey Id: PS-01

	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion? *[The skid trail was located in the center of a type 5 swale for a distance of 88 m. as a minor skid trail and 87 m. as a main skid trail.]	X*		#3,4,11,20 & 21		#9,17,21 & 25	
2. Is there evidence of gully development or other chronic erosion problems? *[minor gullies developing on steep spur trail.]	X*				#4 & 5	
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters? *[steep spur trail connects directly to main trail running down type 5 swale.]	X*					
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?	X		#20 & 22		#15 & 18	
5. Is there evidence that skid trails are re-vegetating? * except steep spur trail.	X*		#3 #22 #25-#5	vs. vs. vs.	#8 #2 #5-#10	
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.*, other than natural re-vegetation)?		X				

Summary:

This survey was established to evaluate erosion and sediment delivery to the stream system from a skid trail that was located partially within a type 5 water. The type 5 water was not buffered on this partial cut harvest unit. The type 5, which is shown on the water type map submitted with the FPA, is an ephemeral drainage swale which has a discontinuous, poorly-defined channel. The survey runs down the center of swale, where the a skidder yarding trail runs for 88 meters before intersecting a major skid trail which runs another 87 meters down the center of the swale before veering off to a road. Slope gradients along the skid trail/swale range from 7% to 24% but are mostly between 10% and 15%. Another short skid trail runs down a steeper side slope of 30-60% and joins the main trail. During both survey years there was flowing and standing water in the upper part of the swale, both upstream of and within the upper part of skid trail section, as well as downstream of the skid trail section where it approaches its confluence with the type 3 stream that is buffered with an RMZ. For most of the section where the skid trail runs, the swale was dry during both survey years, and there was no residual evidence of recent surface flow along this dry section of the swale. Any channel definition that may have existed along this section of the swale would have been obliterated by the skidding activity and the construction of water bars. Water bars were present during both survey years. Revegetation of the skid trails was greatest in the upper portion (75-100% vegetated), above the water bars and the intersection with the major skid trail, and ranged from mostly bare soil to mostly vegetated within the flatter, drier section along the main skid trail. The steep spur trail was still almost 100% exposed soil at the time of the 1994 survey, 17 months following the completion of timber harvest. Minor gullies were noted on lower part of the steep spur trail in the 1994 survey. Flowing and standing water was noted in skidder ruts in the upper portion of the yarding trail during both survey years. The water bars combined with an apparent lack of surface runoff were effective at preventing channelized flow and sediment transport downstream of the skid trail. No transport of sediment was observed downstream of a fill and slash berm constructed where the trail veered out of the swale to intersect a road. Surface flow and moist, wetland conditions resumed in the swale downstream of the skid trail. The practices used at this site did result in localized sediment delivery to the type 5, as well as direct physical disturbance of the drainage and any channel that may have existed there and possibly disruption of the flow regime within the type 5 water. In addition, the bare soils are potentially a chronic source of sediment to the stream system during runoff events. For these reasons, the practice of locating a skidding route down the center of a swale, even an apparently dry swale, is not advisable. However, since surface water and sediment have apparently not been routed beyond the immediate skid trail area, the practice is considered partially effective in this case.

BMP Effectiveness Rating: PARTIALLY EFFECTIVE

Skid Trail Photo Point Survey Summary

Site: Green Canyon Survey dates: 11/6/92
Survey Id: PS-02 4/25/94

	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X				
2. Is there evidence of gully development or other chronic erosion problems?		X				
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters? * While gully erosion was prevented, there is reasonably high potential for delivery to the type 5 stream at the base of this steep skid trail.		n/a*				
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?	X				#23, #24, #2, #7	
5. Is there evidence that skid trails are re-vegetating? ** Skid trail still had >75% exposed soils at all transects, and active surface erosion was observed at 11 of 16 transects in 1994 survey.		X**				
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.*, other than natural re-vegetation)?		n/a				

Summary:
Photo survey PS-02 is the second of four photo point surveys intended to evaluate the effectiveness of water bars in preventing erosion on skid trails after logging activities are completed, and, secondarily, to monitor the rate of revegetation of the soils exposed by the skid trails. The skid trail monitored in the PS-02 survey runs down a relatively steep side slope, and at its base it connects with the main skid trail monitored in the PS-01 survey. Therefore, the potential for delivery of eroded sediment to the type 5 stream covered in the PS-01 survey is reasonably high. The trail begins on a flat above the type 5 stream valley, but on the steep terrain of the valley side slope the trail was constructed with cut and fill slopes, with the trail surface being outsloped. The main findings of the PS-02 survey are: 1) the rate of natural revegetation was very slow; all 16 transects were still >75% exposed 18 months following timber harvest; 2) the water bars were effective at preventing gully erosion, which would have likely led to sediment delivery to the type 5 at the base of the trail, but there was evidence of continuing surface erosion (e.g., sheetwash) on 11 of the 16 transects surveyed; and 3) there was no evidence of fine sediment delivery to the stream from this skid trail over the monitoring period.

BMP Effectiveness Rating: EFFECTIVE

Skid Trail Photo Point Survey Summary

Site: Green Canyon   Survey dates: 11/6/92
Survey Id: PS-03   4/25/94

	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X				
2. Is there evidence of gully development or other chronic erosion problems? *[Minor gullies noted on some sections but these were short and sediment was stored behind water bars.]		X*			#18,22	
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters?	n/a					
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?	X		#21 #3	vs. vs.	#24 #7	
5. Is there evidence that skid trails are re-vegetating?	X				#13,16,17	
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.* , other than natural re-vegetation)?		X				

Summary:

Photo survey PS-03 is the third of four photo point surveys intended to evaluate the effectiveness of water bars in preventing erosion on skid trails after logging activities are completed, and, secondarily, to monitor the rate of revegetation of the soils exposed by the skid trails. The findings of PS-03 are similar to those of PS-01 and PS-02 except in one respect. The rate of natural revegetation was slightly faster than that observed at the other trails. Of the 14 transects evaluated, the percent vegetative cover was 0-25 % for 4, 25-50 % for 5, 50-75 % for 3, and 75-50 % covered for 2 transects. Again, no fine sediment was delivered to surface water and there was no evidence of sediment transport onto or across the road that exists between the skid trail and the type 3 water. The water bars were effective at storing eroded sediment and preventing the development of large gullies, slumps, or other forms of erosion other than surface wash, minor rills, and minor, short gullies.

BMP Effectiveness Rating: EFFECTIVE

Skid Trail Photo Point Survey Summary

Site: Green Canyon (E-04) Survey dates: 11/6/92
Survey Id: PS-04 4/25/94

	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of sediment delivery to surface waters from skid trail erosion?		X	#6, #9		#7, #8	
2. Is there evidence of gully development or other chronic erosion problems? [Only sheetwash and minor rilling.]		X			#3, #4, #6	
3. If answer to No. 2 is "Yes", is there reasonable potential for delivery to surface waters? [Definite potential to deliver from base of skid trail.]	n/a					
4. Is there evidence that waters bars are effective at controlling drainage and preventing chronic erosion problems?	X				#5, #7	
5. Is there evidence that skid trails are re-vegetating?	X		#12 #8 #6	vs. vs. vs.	#15 #10 #8	
6. If answer to No. 5 is "yes", is this due to seeding, mulching, or other efforts to encourage re-vegetation (*i.e.* , other than natural re-vegetation)?		X				

Summary:

Photo survey PS-04 is the fourth of four photo point networks established to evaluate sediment delivery to surface waters from skid trails, the effectiveness of water bars in preventing excessive erosion on skid trails, and monitor the rate of revegetation on the trails. This skid trail came down a relatively steep slope (30% to 45% gradient, with flatter portions at the top and bottom of the surveyed trail) to a landing area near where a road crossed the type 3 stream. At the bottom of the survey, the trail came to within about 4 meters of the stream, with potential to deliver runoff and sediment across the floodplain. Along this section of the stream just upstream of a road crossing, floodplain vegetation consisted only of grasses; there were no trees in the RMZ here, apparently due to historical grazing and land clearing activities. No sediment was delivered to surface waters via the skid trail, although the base of the trail came to within about 4 meters of the type 3 stream. The water bars were effective at preventing the development of gullies, mass wasting, or other chronic erosion problems. The rate of revegetation was much faster at the top and bottom of this trail (75-100% vegetated in 1994), probably due to the flatter ground which allowed for greater soil and seed retention, while the middle portion of the trail which descended a steep slope was much less vegetated at the time of the 1994 survey (0-25% vegetated).

BMP Effectiveness Rating: EFFECTIVE

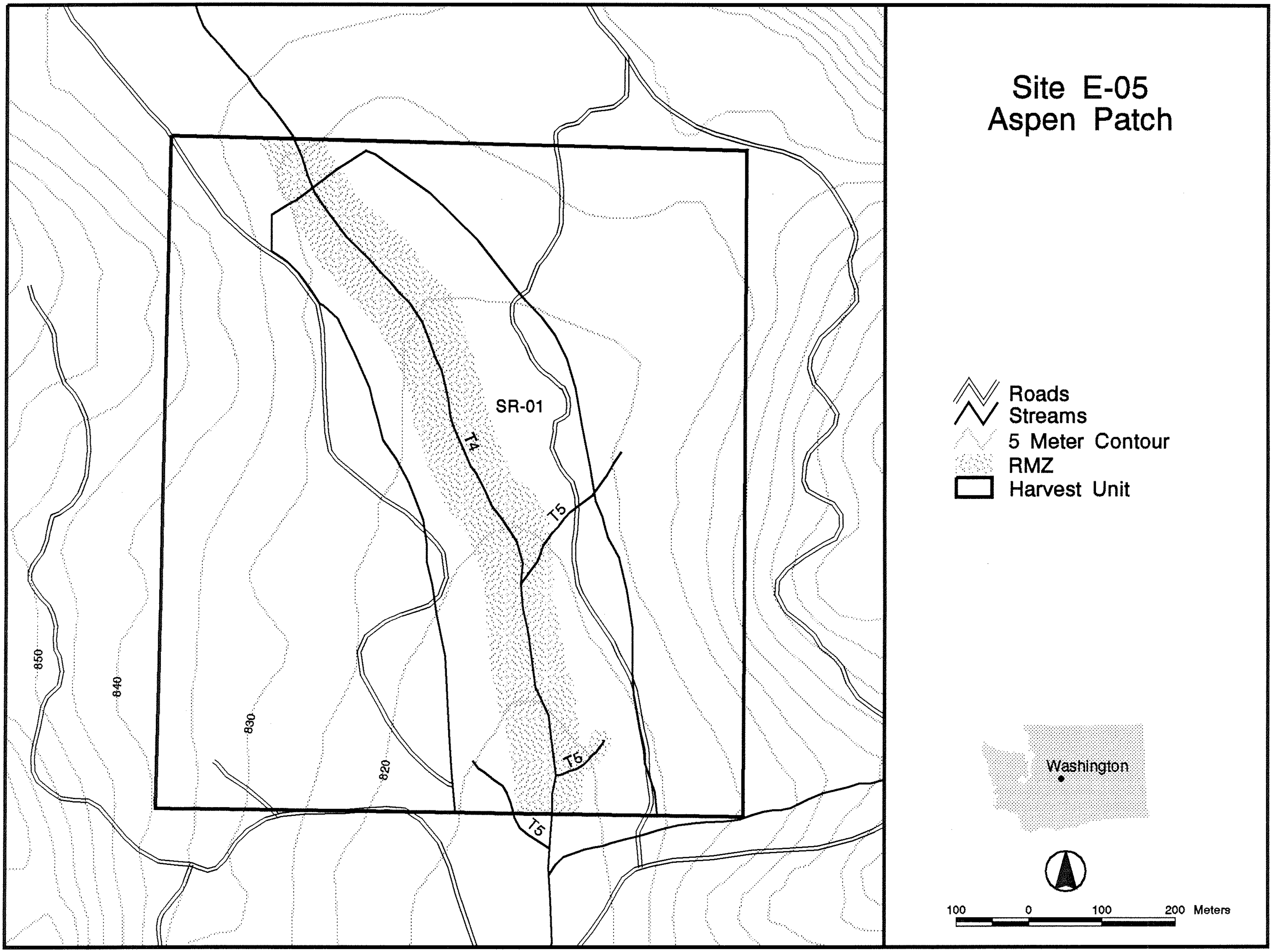
Site E-05: Aspen Patch

The Aspen Patch site is a harvest practice evaluation located in north-central Kittitas County in the Eastern Cascades physiographic region. The surface geology of the site 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 cutbank/fill/sidecast hazard and a medium erosion potential. The harvest BMP slope hazard category for the site is low, with stream valley side slope gradients of less than 5%.

The study stream at this site is a 2nd order, Type 4 stream that is a tributary of the West Fork Teanaway River. The intermittent stream runs through an aspen grove, which was left intact as a RMZ. A forested wetland exists in portions of the RMZ.

Forest practices conducted this site include a 65 hectare partial cut harvest with 60% volume removal, using ground-based yarding methods (tracked and/or wheeled skidders). 0.8 kilometers of road was constructed to access the harvest area, with another 0.2 kilometers of road reconstruction. Harvesting in the vicinity of the survey areas was completed by September 1992.

BMPs evaluated at this site were the RMZ along the Type 4 stream with adjacent ground-based harvesting. Sediment routing surveys were conducted along the entire length of the RMZ in October 1993 and August 1994.



Site E-05
Aspen Patch
Roads
Streams
5 Meter Contour
RMZ
Harvest Unit
SR-01
T4
T5
T5
T6
850
840
830
820
Washington
100
0
100
200 Meters

Study Site: E-05: Aspen Patch - Partial cut harvest with RMZ

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01	Effective					
Case Narrative:	The BMPs evaluated in this case included a wide RMZ left to protect an intermittent type 4 stream and forested wetland from ground-based yarding activities on a partial cut harvest. There was no yarding across the stream or wetland, and no erosion features from timber falling, yarding, or site preparation activities were found to deliver sediment to the type 4 stream. 5 of 24 yarding-related erosion features identified in the sediment routing surveys caused localized disturbance of the perimeter of the wetland, but there was no evidence of surface flow or sediment transport to the stream. Some of the skid trail erosion features identified in the first survey (13 months following harvest) had revegetated by the time of the follow-up survey conducted 23 months following harvest. Two off-road vehicle trails within the survey area crossed the stream and wetland, with sediment delivery to the stream. It was also noted that a haul road crossing of a type 5 swale within the survey area delivered minor amounts of sediment to the type 5.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	No separate in-stream surveys were conducted at this site.						
Case Narrative:	It was observed in sediment routing surveys that there were no sediment-related in-stream effects associated with harvest activities. The only impact on aquatic habitats observed at this study site was localized yarding-related disturbance of the perimeter of a large forested wetland.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Aspen Patch	Survey Date	10/20/93
Site Id #	E-05	Survey Id #	SR-01
Water Type	4	Months Since Harvest	13

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	old windthrow	yes	2.0	not recorded	n/a
2	skid trail	no	14.0	not recorded	n/a
3	skid trail	no	2.0	not recorded	n/a
4	skid trail	no	6.4	not recorded	n/a
5	skid trail	no	49.6	not recorded	n/a
	TOTALS	1 delivered	74.0		

Total Area of Ground Surveyed = 10.4 hectares

Total Length of Stream Bank Surveyed = 1756 meters

Disturbed Soil per Hectare = 7.1 m^2/ha.

Exposed Soil Area per Hectare = Not Determined

***Surface Area Disturbed/Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2**

***Disturbed/Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/hectare**

*Features that delivered but were not directly attributable to current harvest practices, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of **Disturbed** Soil (m^2)	**Disturbed** Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of **Disturbed** soil)
skid trail	4	72.0	0.0	0
windthrow (old)	1	2.0	2.0	100

NARRATIVE:

The forest practices evaluated with this survey were partial cut harvesting using ground-based yarding methods in the vicinity of a type 4 stream buffered by a RMZ. Portions of the RMZ contain a forested wetland. During this preliminary survey, erosion features that disturbed the wetland were not identified, as was done on the follow-up survey. The only erosion feature that delivered sediment to the type 4 stream was the rootwad of an old windthrow, which was obviously down prior to the logging.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Aspen Patch	Survey Date	8/15/94
Site Id #	E-05	Survey Id #	SR-01
Water Type	4	Months Since Harvest	23

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	old windthrow	yes	1.0	75-100	0.9
2	skid trail	no (wetland*)	13.8	25-50	5.2
3	skid trail	no longer eroding - revegetated			
4	skid trail	no longer eroding - revegetated			
5	skid trail	no	76.0	50-75	47.5
1 ('94)	wildlife/livestock	no	15.1	75-100	13.2
2 ('94)	skid trail	no	168.0	25-50	63.0
3 ('94)	skid trail	no	86.1	25-50	32.3
4 ('94)	ORV trail	yes	343.0	0-25	42.9
5 ('94)	yarding	no	9.5	50-75	5.9
6 ('94)	yarding	no	23.3	0-25	2.9
7 ('94)	wildlife/livestock	no	7.5	50-75	4.7
8 ('94)	ORV trail	yes	76.2	0-25	9.5
9 ('94)	skid trail	no	98.4	25-50	36.9
10 ('94)	yarding	no (wetland*)	24.3	25-50	9.1
11 ('94)	skid trail	no	129.0	25-50	48.4
12 ('94)	yarding	no	10.2	75-100	8.9
13 ('94)	skid trail	no	199.5	0-25	24.9
14 ('94)	skid trail	no	64.0	25-50	24.0
15 ('94)	skid trail	no (wetland*)	22.1	25-50	8.3
16 ('94)	skid trail	no	68.0	0-25	8.5
17 ('94)	skid trail	no	180.0	50-75	112.5
18 ('94)	skid trail	no (wetland*)	133.0	25-50	49.9
19 ('94)	skid trail	no (wetland*)	161.0	0-25	20.1
20 ('94)	skid trail	no	5.0	50-75	3.1
21 ('94)	skid trail	no	20.0	25-50	7.5
22 ('94)	skid trail	no	40.5	0-25	5.1
23 ('94)	skid trail	no	37.5	25-50	14.1
24 ('94)	skid trail	no	122.2	25-50	45.8

* disturbed perimeter of forested wetland; no delivery to stream or routing via flowing water

	TOTALS	3 delivered	2134.2		655.1

Total Area of Ground Surveyed = 21.6 hectares

Total Length of Stream Bank Surveyed = 1756 meters

Disturbed Soil per Hectare = 98.8 m^2/ha.

Area Exposed Soil per Hectare = 30.3 m^2/ha

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 53.3 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 2.5 m^2/ha.

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha.**

* Features that delivered but are not directly attributable to current harvest practices, such as windthrow, wildlife or livestock activity, ORV trails, etc., were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	17	554.0	0.0	0
yarding	5	29.9	0.0	0
windthrow (pre-logging)	1	0.9	0.9	1.7
ORV trail	2	52.4	52.4	98.3
wildlife/livestock	2	17.9	0.0	0

NARRATIVE:

The forest practices evaluated with this survey were partial cut harvesting using ground-based yarding methods in the vicinity of a type 4 stream buffered by a RMZ. Portions of the RMZ contain a forested wetland. The large increase in the number of erosion features, and the area of disturbed and exposed soil, is due to a change in the survey area from the previous year. The preliminary 1993 survey covered about half of the area surveyed in 1994, and focused solely on delivery to the type 4 stream channel which meanders roughly through the middle of the RMZ, which averages 34 meters wide on each side of the stream. In 1994, the surveyors covered a wider swath of ground and identified erosion features causing disturbance of the perimeter of the forested wetland associated with the stream and riparian zone (essentially the edge of the aspen-dominated RMZ), in addition to evaluating sediment delivery to the type 4 stream. For this reason, erosion features which were outside the survey boundary in 1993 were surveyed in 1994. The Aspen Patch harvest site is flat ground, with maximum hillslope gradients no greater than 10% in the vicinity of the RMZ. Evidence of overland flow, gully development, or other mechanisms of soil movement were not documented at any of the harvest attributable erosion features. Three erosion features un-related to the harvest (an old windthrow and two off-road vehicle trails) were found to deliver sediment to the type 4 stream. Five of the 22 harvest-related erosion features were found to disturb the perimeter of the forested wetland, but there was no evidence of sediment routing via flowing water.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

Northern Rockies Physiographic Region

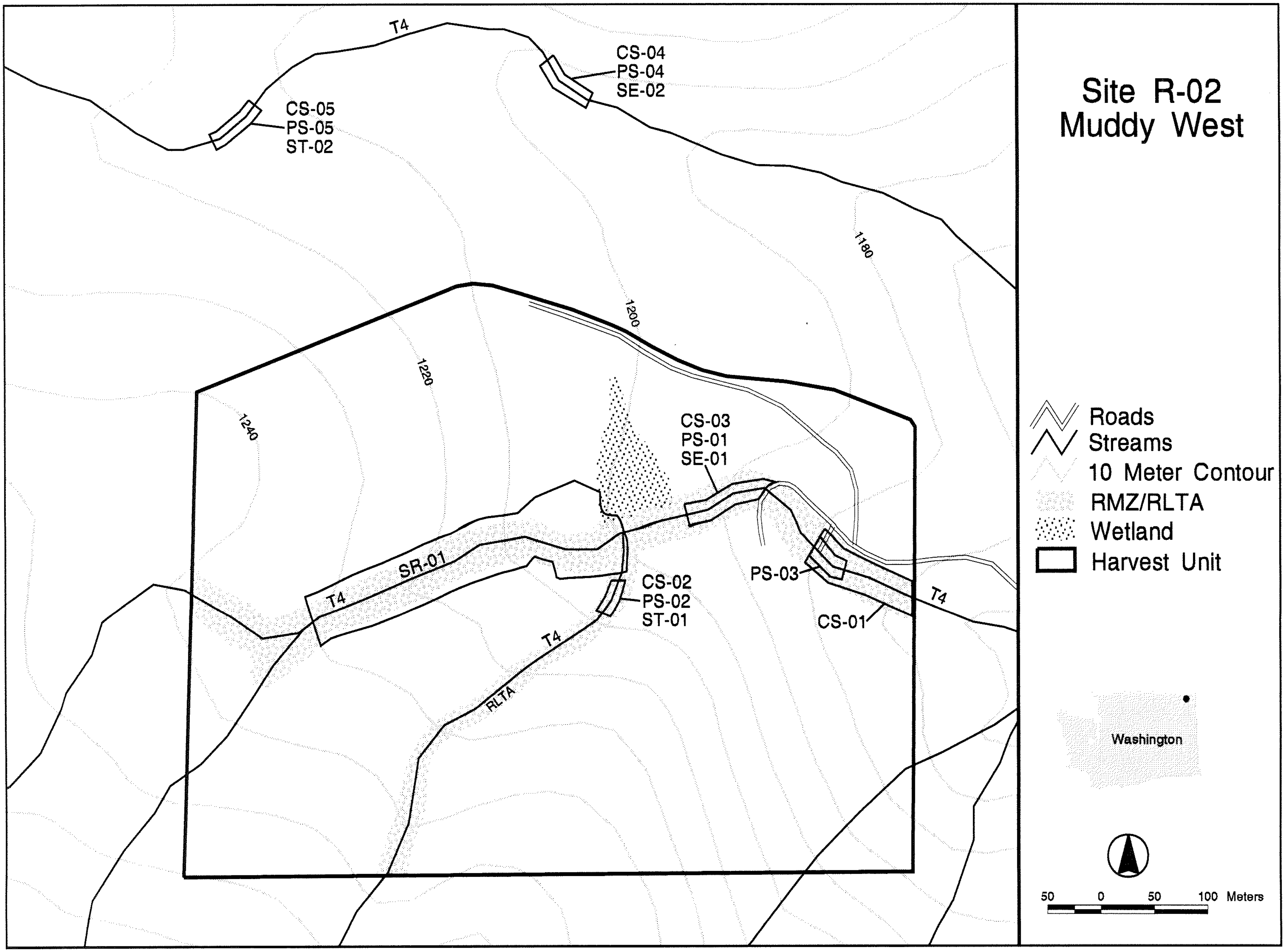
Site R-02: Muddy West

The Muddy West site is located in northwest Pend Orielle County in the Northern Rockies physiographic region. Both harvest and road construction practices were evaluated at this site. Muddy West is part of the CMER Wildlife-RMZ research project, and some of our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the harvest unit is mapped as undifferentiated glacial drift deposits, which overlay granitic bedrock. Soils at the harvest site are mapped as Aits loam (high precipitation), 15-25% slopes. These soils are rated as stable for disturbed slope stability, with a slight cutbank/fill/sidecast hazard and a medium erosion potential. The harvest BMP slope hazard category is high, with stream valley side slope gradients of 21% to 49% along study reaches. The road construction BMP slope hazard category is moderate, with hillslope gradients along the road alignment and at stream crossings generally less than 50%, and averaging 16% and 37% in two survey segments draining to the main stream crossings.

Study streams within the Muddy West harvest unit include a 1st order, Type 4 stream that is a tributary of Big Muddy Creek in the Pend Orielle River basin, and a zero order, Type 4 stream that is a tributary of the main Type 4. The main Type 4 stream has a step-pool channel morphology, with an average active channel width of about 2 meters and average gradient of 10% to 12% in the study reaches. The Type 4 tributary has a step-pool morphology, with an active channel width of 1 meter and an average gradient of 14% in the study reach. The road crosses the main Type 4 stream twice, with additional crossings of Type 4 and 5 tributaries.

Forest practices conducted at this site include a 37 hectare partial cut harvest with 40% volume removal, using ground-based yarding methods. A RMZ was established on the main Type 4 stream (although classified as a Type 4, the perennial stream was treated with a standard regulation Type 3 RMZ for the purposes of the CMER Wildlife-RMZ study). The width of the RMZ averaged 17 meters in the vicinity of the survey areas. A RLTA (9 meters wide in the study reach) was established on the Type 4 tributary. Approximately 3.2 km of road was constructed to access both the Muddy West and Muddy East harvest units, of which 0.8 km was re-construction of an old road. The road construction was completed in October 1993. The timber harvest was completed in January 1994.

BMPs evaluated at this site include the RMZ and RLTA with adjacent ground-based harvesting, and new road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Two in-stream survey reaches were established on the Type 4 stream buffered by the RMZ. Channel condition and photo point surveys were conducted at both reaches in June and July of 1993, August 1994, and June 1995. Stream bank erosion surveys were conducted at the upstream RMZ reach in July 1993 and August 1994. One study reach was established on the Type 4 tributary buffered by the RLTA, with channel condition, photo point, and streambed stability surveys conducted in June and July of 1993, and August 1994. Control reaches for surveys on both Type 4 streams are located in an adjacent drainage just to the north of the harvest area, referred to as the "Muddy Control" site. Riparian amphibian surveys were conducted along the main stream and RMZ and at the Muddy Control site by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project. A sediment routing survey was conducted along a portion of the RMZ in June 1995. Surveys to evaluate road construction BMPs include cutbank/fillslope surveys of two road drainage segments, conducted in November 1993, August 1994, and June 1995. Culvert condition surveys covering over 2 km. of the road were conducted in November 1993 and August 1994, with follow-up measurements of erosion, storage, and sediment deposition in June 1995. In addition, in-stream surveys on the RMZ study reaches mentioned above were used in the evaluation of road effects.


Site R-02
Muddy West
Roads
Streams
10 Meter Contour
RMZ/RLTA
Wetland
Harvest Unit
Washington
50 0 50 100 Meters
T4
CS-04
PS-04
SE-02
CS-05
PS-05
ST-02
1180
1200
1220
1240
CS-03
PS-01
SE-01
SR-01
CS-02
PS-02
ST-01
PS-03
CS-01
RLTA

Harvest BMP Effectiveness Summary

Study Site: R-02: Mudy West - Partial cut harvest, with RMZ and with RLTA.

	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		BMP Effectiveness Ratings: Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing:						
	SR-01	Effective					

Case Narrative: The sediment routing survey evaluated erosion and sediment delivery from ground-based yarding on partial cut harvest areas on both sides of the main type 4 stream (referred to as the "Muddy West" stream) that was buffered by a RMZ. The RMZ was not crossed by timber yarding routes, although it was noted that a limited number of trees were harvested from the RMZ. At the time of the survey conducted 18 months following harvest, distured soils from skid trails and other yarding activity covered 5% of the survey area. None of the erosion features identified in the survey delivered sediment directly to the type 4 stream buffered by the RMZ. One main skid trail was associated with minor amounts of delivery to a type 4 tributary to the main stream. This occured at a crossing of the tributary, which was buffered with a RLTA, but water bars on the skid trail limited sediment delivery to a localized area at the crossing.

	Survey Employed	RMZ Ground-based	RMZ Cable	No buffers Ground-based	No buffers Cable	RLTAs Ground-based	RLTAs Cable
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:						
	CS-01/CS-04	Effective					
	CS-02/CS-05					Effective	
	CS-03/CS-04	Effective					
	Photo Point:						
	PS-01/PS-04	Effective					
	PS-02/PS-05					Effective	
	PS-03/PS-04	Effective					
	Stream Bank Erosion:						
	SE-01B/SE-02	Effective					
	Streambed Stability						
	ST-01/ST-02					Effective	

Case Narrative: Channel condition and photo point surveys in the two RMZ treatment reaches did not show adverse effects associated with timber harvesting. Both study reaches were affected by road construction activities (a road crossing disturbed the lower end of the CS-03 reach, and an aborted road crossing disturbed the upper end of the CS-01 reach), and in both cases the in-stream degradation observed was attributed to road effects. Photo point surveys in the RMZ study reaches did not document any windthrow over the 18-month post-harvest monitoring period. Stream bank erosion surveys in the RMZ study reach showed slight increases in bank erosion attributed to scour by stream flows and wildlife activity, but no bank disturbance associated with timber harvest activities. (Note: following preliminary surveys on the SE-01 study reach, the lower portion of the reach was affected by a road crossing, so for follow-up surveys, the reach was split into SE-01A and SE-01B.) In-stream surveys evaluating the type 4 tributary buffered with a RLTA showed very little change in stream channel conditions associated with timber harvest activities. Harvest of trees occurred within the RLTA. The photo point surveys documented increases in small woody debris and 20 new trees across the channel, either windthrown or knocked down during harvest, over a 26 meter reach. The streambed stability surveys showed increases in the total volume of in-channel sediment storage in both treatment and control reaches. 13 individual sediment wedges identified in the treatment reach remained stable over the monitoring period.

		RMZ Ground-based	RMZ Cable	No buffers Ground-based	No buffers Cable	RLTAs Ground-based	RLTAs Cable
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE				EFFECTIVE	

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Muddy West	Survey Date	6/22/95
Site Id #	R-02	Survey Id #	SR-01
Water Type	4	Months Since Harvest	18

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	yes	306.6	0-25	38.3
2	skid trail	no	1.1	75-100	1.0
3	skid trail	no	31.9	0-25	4.0
4	skid trail	no	46.2	50-75	28.9
5	skid trail	no	19.3	25-50	7.3
6	skid trail	no	694.6	25-50	260.5
7	yarding	no	3.6	50-75	2.3
8	windthrow	no	2.4	50-75	1.5
	TOTALS	1 delivered	1105.7		343.8

Total Area of Ground Surveyed = 2.2 hectares

Total Length of Stream Bank Surveyed = 822 meters

Disturbed Soil per Hectare = 502.6 m^2/ha.

Area Exposed Soil per Hectare = 156.3 m2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 38.3 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 17.4 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 38.3 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 17.4 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	6	340.0	38.3	100
yarding	1	2.3	0.0	0
windthrow	1	1.5	0.0	0

NARRATIVE:

Forest practices evaluated with this survey were partial-cut harvesting using ground-based yarding methods on both sides of a type 4 buffered with a standard regulation "type 3" RMZ. The skid trail that delivered sediment crossed a type 4 tributary to the main type 4 stream. The tributary was buffered with a RLTA, and the skid trial crossing was made perpendicular to the channel. Unambiguous sediment delivery was observed only at a localized area in the immediate vicinity of the crossing. There was no evidence of surface erosion or gully development on the skid trail, which was water barred to divert drainage and sediment away from the crossing. Although there was some slight amount of sediment delivery to the tributary, the RMZ, which averaged 17 meters wide in the vicinity of the survey area and was not yarded across, was effective at preventing direct sediment delivery to the main stream from harvest site erosion.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Muddy West R-02
Treatment Survey ID#: CS-01 Water Type: 4
Control Survey ID#: CS-04 (@ Muddy Control Site) Water Type: 4

BMP(s) Evaluated: RMZ with Partial Cut Harvest (Ground-based Yarding)
New Road Construction (Stream Crossings)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	61	6/1/93	61	6/1/93
Post-Treatment Survey #1:	45	8/23/94	55	8/24/94
Change from Pre-Treatment Score:	-16		-6	
Net Change (Control-Treatment):	-10			
Post-Treatment Survey #2:	51	6/20/95	61	6/20/95
Change from Pre-Treatment Score:	-10		0	
Net Change (Control-Treatment):	-10			

BMP EFFECTIVENESS CALL: Effective (RMZ)
Not Effective (Road Stream Crossing)

Case Narrative:

The treatment study reach is located on the main "Muddy West" stream buffered by a RMZ, and is downstream of the main road crossing; an aborted spur road crossing disturbed the upper section of the reach. The control reach is in an adjacent drainage at the "Muddy Control" study site. Both study reaches have step-pool morphologies with average channel gradients of 12% and 8%, respectively for treatment and control reaches. The change in score for the treatment reach is attributable to observations of increased stream bank erosion, increased streambed mobility and destabilization of sediment storage elements associated with small WD, and increased extent and depth of fines in pools. The degradation in stream channel condition is attributed primarily to disturbance associated with the aborted spur road crossing that impacted the upstream end of the treatment reach. Sediment from the stream bank erosion at this crossing site was observed as fresh, mobile sediment deposits throughout the reach. There was no evidence of sediment delivery to or direct disturbance of the study reach attributable to timber falling or yarding activity. Little overall change in stream channel integrity or sediment deposition was noted in the control reach over the monitoring period. The changes in score for the control reach between the 1993 and 1994 surveys reflected an increased fines in pools, increased streambed mobility, and a shift in dominant particle size from gravels and cobbles to fines. These decreases in channel condition score in the control reach were offset by observations of slightly reduced bank erosion and decreased non-pool fines. In 1995, the control reach score was the same as pre-treatment.

In-Stream Photo Point Survey Comparison Summary

Site: Muddy West Survey Dates: 7/93, 8/94 and 6/95
RMZ Reach below new road

Indicators of in-channel changes	Control PS-04 Yes	Control PS-04 No	Treatment PS-03 Yes	Treatment PS-03 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X	X	
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X	X	
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X	X	
4. Is there evidence of increased deposition or storage of fine or course sediment?		X	X	
5. Are there changes in woody debris?				
Increase in large WD?		X		X
Increase in small WD?	X		X	
Decrease in WD?	X		X	
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X		X

Summary:
The treatment reach was substantially altered by an attempt to cross the stream. This crossing was abandoned, with the actual crossing occurring upstream about 75 meters. This crossing lead to loss of stream bank integrity, delivery of fine and coarse material to the stream channel, and destabilization of sediment storage elements associated with woody debris. Changes in the treatment reach were substantially greater than in the control. An increase in SWD was noted in both study reaches, with some SWD pieces also mobile from year to year.

BMP Effectiveness Call: Not Effective

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Muddy West R-02
Treatment Survey ID#: CS-03 Water Type: 4
Control Survey ID#: CS-04 (@ Muddy Control Site) Water Type: 4

BMP(s) Evaluated: RMZ with Partial Cut Harvest (Ground-based Yarding)
New Road Construction (Stream Crossings)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	55	7/28/93	61	6/1/93
Post-Treatment Survey #1:	45	8/24/94	55	8/24/94
Change from Pre-Treatment Score:	-10		-6	
Net Change (Control-Treatment):	-4			
Post-Treatment Survey #2:	48	6/20/95	61	6/20/95
Change from Pre-Treatment Score:	-7		0	
Net Change (Control-Treatment):	-7			

BMP EFFECTIVENESS CALL: Effective (RMZ)
Not Effective (Road Stream Crossing)

Case Narrative:

The treatment study reach is located on the main "Muddy West" stream buffered by a RMZ, and is upstream of the main road crossing. The control reach is in an adjacent drainage at the "Muddy Control" study site. Both study reaches have step-pool morphologies with average channel gradients of 10% and 8%, respectively for treatment and control reaches. The change in score for the treatment reach is attributable to observations of increased stream bank erosion, increases in fresh sediment deposits, increased streambed mobility. The degradation in stream channel condition is attributed primarily to disturbance associated with the culvert installation that occurred at the downstream end of the study reach. Streambed changes associated with the culvert installation resulted in the destabilization of streambed control elements, including a relict beaver dam, that were just upstream of the crossing. The resulting downcutting, streambed scour, and bank erosion affected the lower 24 meters of the study reach. The surveyors noted after the road construction that this treatment reach looked like two different streams above and below the area affected by the culvert installation. Consequently, some of the channel condition survey elements were scored as an average of two separate observations. Thus, although the overall reach score did not decrease by more than 10 points as compared to the control, it is clear that the lower section would have exceeded this threshold, resulting in a "not effective" rating for stream crossing practices. It was noted that the upper 62 meters of the reach appeared very stable, including the finer substrate and small WD. There was no evidence of sediment delivery to or direct disturbance of the study reach attributable to timber falling, yarding, or nearby skid trails, although some trees were harvested from the RMZ.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey (Treatment)

Site: Muddy West	Treatment (Partial Cut Harvest w/ RMZ)		
Survey Dates: 7/93 & 8/94	Water Type: 4		
Survey #: SE-01B	Total reach length center line:		62 M
	Length of left bank:		73 M
	Length of right bank:		83 M
	Total Bank length:		156 M
	Year		
	1993	1994	
Total # eroding banks	0	2	
Total # Sampled	0	2	
Total length of eroding banks	0.0 M	4.8 M	
Total area of eroding banks	0.0 sq. m.	1.1 sq. m.	
% of bank length eroding:	0%	3%	
Cause of Bank Erosion:	Length of Eroding Bank:		
Wildlife	0	0.8 M	
Flowing Water	0	4.0 M	

Stream Bank Erosion Survey (Control)

Site: Muddy Control	Control		
Survey Dates: 7/93 & 8/94	Water Type: 4		
Survey #: SE-02	Total reach length center line:		51 M
	Length of left bank:		66 M
	Length of right bank:		65 M
	Total bank length:		131 M
	Year		
	1993	1994	
Total # eroding banks	0	0	
Total # Sampled	0	0	
Total length of eroding banks	0.0M	0.0 M	
Total area of eroding banks	0.0 sq. m.	0.0 sq. m.	
% of bank length eroding	0%	0%	
Cause of Bank Erosion:			
N/A			

Forest practices evaluated with this survey were partial-cut harvesting using ground-based equipment with an RMZ buffering the type 4 stream. As can be seen from the cause analysis, although there was a slight increase in bank erosion in the treatment reach due to wildlife activity and scour by flowing water, mechanical disturbance of the banks via timber falling, skidding, yarding, etc. did not occur. The control reach used for comparing stream bank responses at Muddy West was also used as the control for the Muddy East site. The banks of the control reach remained stable over the monitoring period.

BMP Effectiveness Rating: EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Muddy West R-02
Treatment Survey ID#: CS-02 Water Type: 4
Control Survey ID#: CS-05 (@ Muddy Control Site) Water Type: 4

BMP(s) Evaluated: RLTA with Partial Cut Harvest (Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	59	6/1/93	62	8/25/93
Post-Treatment Survey #1:	56	8/23/94	60	8/24/94
Change from Pre-Treatment Score:	-3		-2	
Net Change (Control-Treatment):	-1			

BMP EFFECTIVENESS CALL: Effective

Case Narrative:
The RLTA treatment study reach is located on the type 4 tributary of the main "Muddy West" stream. The control reach is in an adjacent drainage at the "Muddy Control" study site. Both study reaches have step-pool morphologies with average channel gradients of 14% and 10%, respectively for treatment and control reaches. Very little change in channel condition was observed in either the treatment or control reach over the monitoring period. The change in score for the treatment reach is attributable to observations of slightly increased stream bank erosion and increases in the extent of non-pool fines on the substrate. The slight decrease in the control reach score over the same monitoring period is attributable to an overall fining of the streambed, although the extent of fines in pools decreased. There was no evidence of direct stream channel disturbance within the study reach attributable to timber falling, yarding, or nearby skid trails, although a number of trees were harvested from the RLTA.

Site R-02: Muddy West - Streambed Stability Survey Results

Treatment Reach: Type 4 Stream with RLTA

Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)	Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)
7/29/93	ST-01	1	0.4	8/23/94	ST-01	1	0.6
		2	0.5			2	0.7
		3	2.9			3	5.5
		4	1.3			4	0.4
		5	0.8			5	1.0
		6	0.2			6	0.2
		7	0.1			7	0.1
		8	0.2			8	0.4
		9	0.4			9	0.9
		10	0.6			10	0.5
		11	0.2			11	0.1
		12	0.7			12	0.7
		13	0.8			13	1.0
Total Volume Stored in Reach (m^3):			9.1				12.1
Average Volume of Sediment Deposits (m^3):			0.7				0.9
Reach Length (meters):			39				39
In-Channel Sediment Storage (m^3/100m):			23.3				31.0

Case Narrative:

These survey results reflect a slight increase in in-channel sediment storage over the monitoring period. All of the individual sediment wedge deposits were stable over the period.

BMP Effectiveness Rating: EFFECTIVE

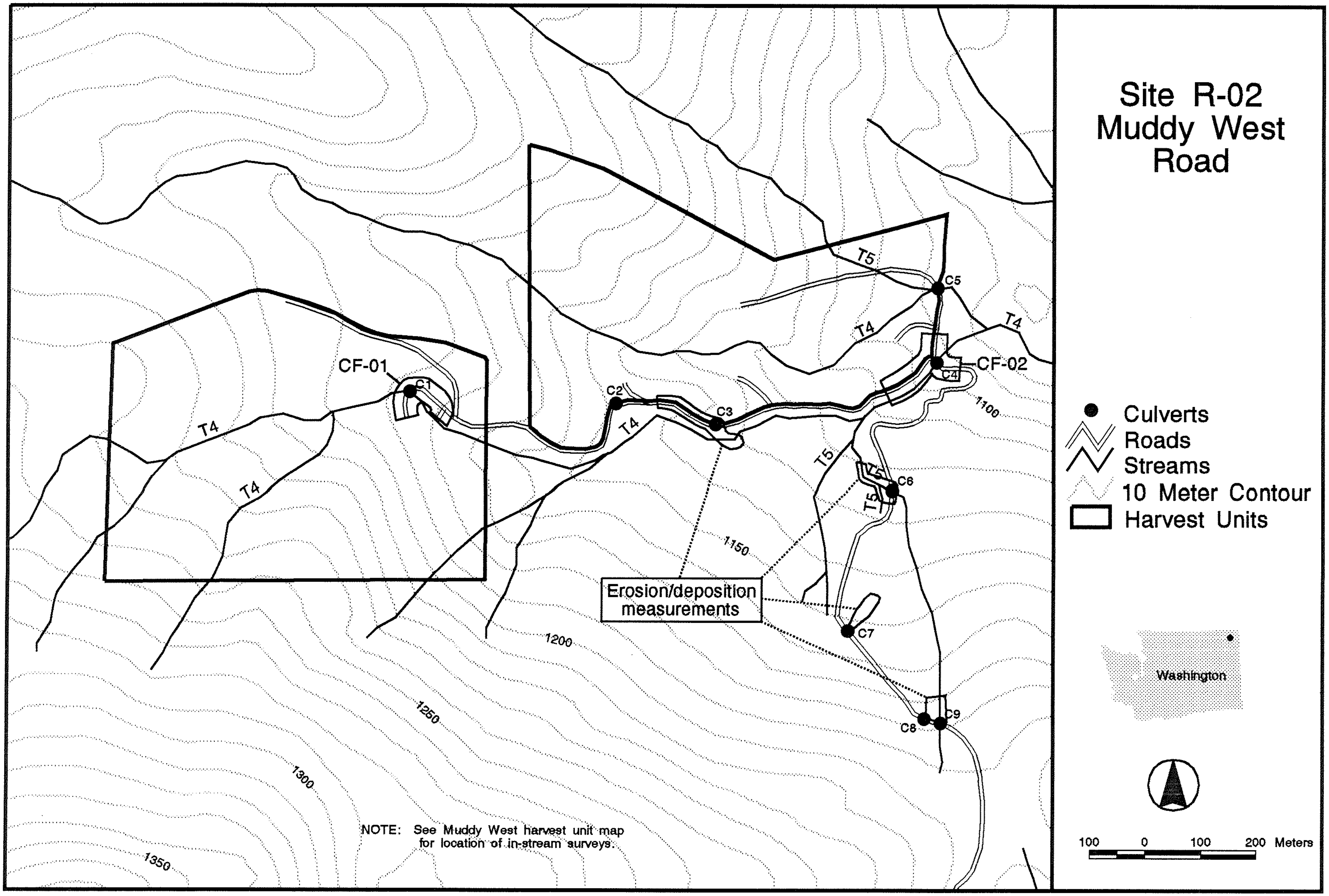
Site R-02: Muddy West - Streambed Stability Survey Results

Control Reach: Type 4 Stream at Muddy Control

Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)	Survey Date	Reach/Survey ID	Sed. Dep. #	Vol. Stored (m3)
11/4/93	ST-02	1	0.3	8/24/94	ST-02	1	0.5
		2	0.3			2	absent
		3	0.1			3	0.3
		4	0.4			4	0.3
		5	0.7			5	0.7
		6	0.3			6	0.4
		7	1.1			7	1.8
		8	0.5			8	0.7
		9	0.4			9	0.4
		10	0.2			10	0.1
		11	1.1			11	1.6
		12	1.2			12	1.2
		13	0.5			13	0.5
		14	0.2			14	0.2
		15	0.8			15	0.9
Total Volume Stored in Reach (m^3):			8.1				9.6
Average Volume of Sediment Deposits (m^3):			0.5				0.7
Reach Length (meters):			41				41
In-Channel Sediment Storage (m^3/100m):			19.8				23.4

Case Narrative:

These survey results reflect a slight increase in in-channel sediment storage over the monitoring period. All but one of the individual sediment wedge deposits were stable over the period; deposit no. 2 was not present in the follow-up survey because the small woody debris storage element had shifted position.


Site R-02
Muddy West
Road
Culverts
Roads
Streams
10 Meter Contour
Harvest Units
Washington
100 0 100 200 Meters
CF-01
C1
C2
C3
C4
C5
C6
C7
C8
C9
CF-02
T4
T5
1100
1150
1200
1250
1300
1350
Erosion/deposition
measurements
NOTE: See Muddy West harvest unit map
for location of in-stream surveys.

Road BMP Effectiveness Summary

Study Site: R-02: Muddy West - New Road Construction

		BMP Effectiveness Ratings			
	Survey Employed	Culvert BMPs		Road Construction BMPs	
		Stream Xings WAC 222-24-040	Relief WAC 222-24-025	Cutslopes WAC 222-24-030	Fillslopes
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition:				
	CC-01	Not Effective	Partially Effective		
	Cutbank/Fillslope:				
	CF-01	Not Effective		Effective	Effective
	CF-02			Not Effective	Not Effective

Case Narrative: The total length of new road construction surveyed in the culvert condition surveys was 2,178 meters, which included 9 culverts and numerous water bars installed following timber harvest. One of four relief culverts delivered sediment to a type 4 stream, and at least 5 of the 50 water bars installed to relieve road drainage delivered sediment to streams within the first year following road construction, leading to a partially effective call for road drainage BMPs. Sediment transport distances downslope of relief culvert outfalls ranged from less than 1 meter to 80 meters. Erosion of culvert fills at the five stream crossings was continuing at moderate to severe levels about one year following road construction, and gully erosion was observed at three of the five crossings. In-stream deposition of eroded material was observed, covering the streambed substrate for a distance of 20-100 meters downstream at four of the crossings. Three of the five stream crossing culverts had outfalls hanging above the streambed at elevations of 0.3 to 0.5 meters. An aborted stream crossing at a spur road (included in the CF-01 survey) was also a source of chronic sediment delivery to the main type 4 stream. Cutslope erosion continued at moderate to severe levels due to the highly erodible soils and a lack of adequate revegetation practices (dry grass seeding was not effective at stabilizing road cuts). At one of the two drainage segments where cutslope practices were evaluated (CF-02 segment), cutslopes were still over 75% exposed 22 months following road construction, resulting in chronic sediment delivery via sediment transport in ditches draining to the type 4 stream crossing. Types of erosion observed in this segment included mass erosion and severe gully erosion on cutslope and ditch. Despite chronic cutslope erosion in the CF-01 drainage segment, and delivery of eroded material that occurred in the first few months following road construction, there was no evidence of chronic sediment delivery. This relatively flat drainage segment was partially outsloped, and although slightly insloped in places, did not have a ditch constructed at the toe of the cutslope. Chronic sediment delivery from fillslope erosion occurred in the CF-02 segment, associated with gully erosion (caused by discharges from water bars), sheetwash erosion, and sidecast ravel from fillslopes constructed within 10 meters of a stream. In the CF-01 segment, chronic delivery of material eroded from fillslopes was limited to the immediate vicinity of the culvert fill, although minor amounts of fillslope sediment delivered to the floodplain from a short fillslope section located within 6 meters of the stream.

		Stream Xings	Relief	Cutslopes	Fillslopes
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:				
	CS-01/CS-04	Not Effective		Indeterminate	Indeterminate
	CS-03/CS-04	Not Effective			
	Photo Point:				
	PS-03/PS-04	Not Effective		Indeterminate	Indeterminate
	PS-01/PS-04	Not Effective			
	Stream Bank Erosion:				
	SE-01A/SE-02	Not Effective			
	Deposition Surveys:	Not Effective	Partially Effective		

Case Narrative: The channel condition and photo point surveys reflect increases in stream bank erosion, sediment deposition and streambed destabilization in the study reach that is downstream of the road crossing at culvert C1, and as well as in the study reach immediately upstream of the same crossing. In the downstream reach (surveys CS-01 and PS-03) the degradation in stream channel condition is attributed to disturbance associated with an aborted spur road crossing. In the upstream reach (surveys CS-03 and PS-01), streambed changes associated with the culvert installation resulted in the destabilization of streambed control elements, including a relict beaver dam, that were just upstream of the crossing. The resulting downcutting, streambed scour, and bank erosion affected the lower 24 meters of the study reach. The increased bank erosion was also measured in the stream bank erosion surveys conducted on the same study reach, whereas above the area affected by the road crossing, stream banks remained stable. Deposition surveys conducted in conjunction with the culvert condition survey, measured the volume of erosion, hillslope storage, and unambiguous, in-stream deposits of material eroded from road sites. In-stream deposition of material eroded from culvert fills plus erosion from road drainage segments (e.g., from road cuts and ditches) ranged from 2 to >17 cubic meters. One of two relief outfalls resulted in in-stream deposition, while the other had 50 cubic meters of sediment stored on the hillslope with no delivery to streams over the monitoring period.

OVERALL SITE BMP EFFECTIVENESS RATING:	NOT EFFECTIVE	PARTIALLY EFFECTIVE	PARTIALLY EFFECTIVE	PARTIALLY EFFECTIVE

Muddy West Culvert Condition Survey Results

Site: R-02: Muddy West
Culvert Condition Survey

Survey dates: 11/3/93, 8/25/94, & 9/15/94
Date of Construction:

Site BMP Effectiveness Ratings:
Stream X-ing: Not Effective
Relief : Partially Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year		Culvert Spacing/ (Drainage Distance*)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	BMP Effectiveness Call (Yes or No))
		1993	1994						
Culvert C-1	Inflow	Moderate	Moderate	46m	Constant	Y	n/a	Y	No
Type 4 x-ing	Outflow	Slight	Moderate	(147m)	Increase				
Culvert C-2	Inflow	Slight	Severe	460m	Increase	Y	No	No	Yes
Relief	Outflow	Slight	Severe	n/a	Increase				
Culvert C-3	Inflow	Slight	Severe	161m	Increase	Y	Yes,	Yes	No
Relief	Outflow	Moderate	Severe	(126m)	Increase		20m overland flow		
Culvert C-4	Inflow	Moderate	Severe	421m	Increase	Y	n/a	Yes	No
Type- 4 x-ing	Outflow	Moderate	Severe	(194m)	Increase				
Culvert C-5	Inflow	Moderate	Severe	131m	Increase	Y	n/a	Yes	No
Type-4 x-ing	Outflow	Slight	Moderate	(105+m)	Increase				
Culvert C-6	Inflow	Moderate	Severe	375m	Increase	Y	n/a	Yes	No
Type-5 x-ing	Outflow	Slight	Severe	(358m)	Increase				
Culvert C-7	Inflow	Slight	Severe	358m	Increase	Y	Yes,	No	Yes
Relief	Outflow	Slight	Severe	(203m)	Increase		80m overland flow		
Culvert C-8	Inflow	Moderate	Severe	203m	Increase	Y	Yes,	No	Yes
Relief	Outflow	Slight	Severe	(23m)	Increase		14 m overland flow		
Culvert C-9	Inflow	Slight	Severe	n/a	Increase	Y	n/a	Yes	No
Type-5 x-ing	Outflow	Slight	Severe	(47+m)	Increase				

* Drainage distance is for first year, prior to water bar installation.

Comments/ Notes Summary
on following page.

<u>Waterbar Summary</u>

Location:	#	Avg. spacing	Delivery to Surface Waters?
C-1 to C-2	10	44M	No
C-2 to C-3	2	53M	No
C-3 to C-4	10	38.2M	No
C-5 spur Rd	4	26M	No
C-4 to C-6	14	27M	Yes, 3 of the 14 water bars delivered to Type 4 @ C4 crossing.
C-6 to C-7	7	45M	Yes, 2 of the 7 delivered to type 5 paralleling road.
C7- to C-8	3	32M	No
C-8 to C-9	0	n/a	n/a

Muddy West Culvert Condition Survey: Notes Summary

The total road length surveyed was 2,178 meters. The average spacing between culverts was 242 meters, and the average road gradient was 9%. In 1993, at culvert C-1, fresh sediment deposition was noted in the stream 7 meters downstream from the outflow; in 1994, the culvert outflow was hanging 0.5 meters above the streambed and sediment deposition was observed 20 meters downstream, including large, in-channel bar deposits. There is no ditch between culverts 1 and 2. Tension cracks in the road fillslope were noted in 1993 at culvert 2. Despite the presence of a slash berm at the outflow of culvert 3, fresh sediment was delivered to the type4 "Muddy West" stream, 20 meters downslope via overland flow. No ditch exists between culverts 3 and 4. Water bars were installed after timber harvesting, in February 1994, and during follow-up maintenance in May 1994. 5 of the 50 water bars were found to deliver sediment to streams located near the road during the survey conducted in 1994. In addition, several of the water bar discharges were observed to transport sediment past slash piles left as sediment traps. The fill material at culvert 4 was failing and delivering sediment to the stream as of 1994. Culvert 5 was placed on a spur road crossing of Muddy East creek; in-channel, fresh sediment deposits and turbid water were documented at the outflow in 1993. By the 1994 survey, the channel had incised 0.3 meters at the outflow of culvert 5. In 1993, fresh sediment was noted 2.5 meters downstream of the outflow of culvert 6. By 1994, extensive sediment deposits traveling at least 100 meters downstream were documented in the Type 5 stream below culvert 6. Rutting in the ditch was documented between culverts 6 and 7 in 1993. A sediment plume downslope of relief culvert C7 less than 1 meter at the time of the 1993 survey, extended down the hillslope for 80 meters via overland flow by the 1994 survey. Culvert 8 had rutting and a small gully on the fill in 1993. By 1994, a sediment plume had extended 14 meters downslope but had not delivered sediment to a nearby type 5 stream. However, culvert 8 only relieves 23 meters of the road drainage. Fresh sediment deposits were documented in the channel 12 meters downstream at culvert 9 in 1993. In 1994, fresh sediment was documented 37.4 meters down stream from culvert 9.

In June 1995, erosion volume measurements were made at several of the culverts, which accounted for the volume of eroded soil, sediment storage on the hillslope, and estimates of the volume of in-stream sediment deposits. The results are as follows:

Culvert 3 is a relief culvert that delivered sediment to Muddy Creek. Sediment volume estimates were made for: 1.) surface erosion on the cutslope, 2.) the volume of a gully in the road ditch, 3.) the sediment stored on the hillslope between the culvert outflow and the point of delivery, and, 4.) a distinct, continuous in-stream sediment deposit within the first 7 meters of the point of delivery. Obvious, bright sediment deposits continued for at least 32 meters downstream of the point of delivery.

1.) Cutslope Surface Erosion = 12.0 cubic meters
2.) Ditch Gully Erosion = 4.8 cubic meters
3.) Hillslope storage = 1.7 cubic meters
4.) Instream Sediment Deposit = 0.35 cubic meters

The estimated volume of sediment delivered to the stream from the gully in the ditch alone* =
4.8 m^3 (ditch erosion) - 1.7 m^3 (hillslope storage) = 3.1 m^3

* eroded cutslope material not stored in the ditch is an additional amount of up to 12 m^3 not included in the above estimate.

Culvert 4 is a stream crossing with 8 gullies on the culvert fill which delivered to the stream. The estimated volume eroded and delivered from the gullies alone = **3.1 cubic meters.**

Culvert 5 is located on a spur road as a stream crossing. Gullies on the fill material which delivered sediment to the stream were measured. The estimated volume which eroded and delivered to the stream = **.66 cubic meters.**

Culvert 6 is a stream crossing at a type 4 water. The measured volume which eroded and delivered to the channel from gully erosion on the fill alone = **0.13 cubic meters.** The estimated volume of a sediment deposit located in the type 5 stream (upstream of the confluence of a type 5 tributary water that was impacted by sediment delivery from a water bar) = **8 cubic meters.**

The volume of sediment which delivered via the waterbar to the type 5 which is a tributary to the type 5 crossed by culvert 6 was estimated to = **4.5 cubic meters.** The length of stream measured was 24 meters. (An additional 5-10 cubic meters of fresh sediment deposition was observed downstream of the confluence of the tributary.)

Culvert 7 is a relief culvert that was depositing a large volume of sediment on the hillslope. This deposit **did not deliver** sediment to a surface water in either 1993, 1994, or 1995, however, overland flow and sediment deposition from the relief culvert was measured at **80 meters** downslope of the relief outfall in 1994. The estimated volume of the sediment deposit = **50.1 cubic meters.**

Culvert 9 is located at a type 5 stream crossing. The estimated volume of sediment which eroded via surface erosion and delivered to the stream = **0.06 cubic meters.** A sediment deposit measured in the channel downstream of the culvert outflow = **2.0 cubic meters.**

CUTSLOPE/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Muddy West
Survey Id #'s	CF-01
Survey Dates	11/3/93 & 8/25/94
Water Type	4
Construction Date:	10/1993

Length Road Draining to Stream	147 meters	Range Road Gradient	0-7 %
		Average Road Gradient	3 %
		Range Hillslope Gradient	5-27 %
		Average Hillslope Gradient	16 %
		Range Cutslope Gradient	32-42 deg.
		Average Cutslope Gradient	38 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	100		100	
% Observations w/med. slope height	0		0	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed soil	0	0	0	0
% Observations w/26-50 % exposed soil	0	0	0	17
% Observations w/51-75 % exposed soil	0	17	0	17
% Observations w/76-100 % exposed soil	100	83	100	66
% Observations w/Evidence of Erosion	100	100	100	100
Evidence of Erosion w/delivery to surface water	yes	no	Only at culvert fill* (*Minor delivery to flood plain in 1994)	
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	no	no	no
BMP Effectiveness Ratings:	**Effective**		**Effective**	

Aborted Stream Crossing @ Spur Road: Not Effective

COMMENTS:

The forest practices evaluated with this survey are new road construction practices for cut and fill slopes in a road segment draining to a crossing of the main type 4 "Muddy West" stream, as well as an aborted crossing of the same stream on a spur road within the drainage segment. At this aborted spur road crossing, the road had been "roughed in" to the left stream bank, and both banks and the stream bed had been disturbed, apparently in preparation for culvert installation. This crossing may have been intended for a spur road to access the southeast corner of the harvest unit, or it may have been intended as the main road crossing. The crossing was probably aborted due to the steep nature of the stream valley side slopes on the far side of the stream, where the road would have switched-back through the RMZ. In any case, the road crossing was made approximately 100 meters upstream at a flat crossing site. No measures were employed to stabilize the stream banks at the aborted crossing site, other than possibly dry grass seeding, which was not effective. The road surface within the study segment consisted of native soils; rock was not used as surfacing material which is typical of road construction in this physiographic region. The road surface design ranged from flat or slightly outsloped to slightly insloped, without

Muddy West CF-01 (cont.)

a purposefully constructed ditch. The types of erosion observed in 1993 were ravel and sloughing for both the cut and fillslopes. There was sediment delivery of material eroded from the cutslope and road surface to the inflow of the culvert. The fill at the outflow of the culvert prism was delivering sediment, but the remainder of the fillslope was not delivering sediment to the stream. In 1994, the types of erosion observed on the cutslope included sloughing and slumping, skidder ruts, and surface erosion. Sediment delivery from both the cut and fillslopes was limited to the immediate area of the culvert installation. The partially outsloped road design and absence of a defined ditch at the toe of the cutslope that drains directly to the stream crossing, combined with the gentle topography along this road segment, prevented chronic sediment delivery of eroded material to the stream. A minor amount of fillslope sediment was observed to deliver to the floodplain of the stream, with potential delivery to the stream during high flows. This occurred along a section where the fillslope was located within 4-6 meters of the stream paralleled by the road. The magnitude of sediment deposition on the floodplain was minor, and there was no gullying or channel development that extended beyond the slash berm at the base of the fillslope, so this is not considered to be a chronic source of sediment delivery. The primary source of sediment delivery to the stream in both survey years was the aborted stream crossing. Unambiguous in-stream deposition of the bright, fresh sediment from the disturbed area was observed to extend 12 meters downstream of the crossing site in 1993, and up to 100 meters downstream 1994. The left bank area was still nearly 100% exposed in 1994. It was also observed in 1993 that the stream became turbid as it flowed past the aborted crossing site.

CUTSLOPE/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Muddy West
Survey Id #'s	CF-02
Survey Dates	11/3/93 & 6/20/95
Water Type	4
Construction Date:	10/1993

Length of Road Draining to Stream: 194 meters

Range Road Gradient	3-17 %
Average Road Gradient	11 %
Range Hillslope Gradient	12-55 %
Average Hillslope Gradient	37 %
Range Cutslope Gradient	32-50 deg.
Average Cutslope Gradient	42 deg.

	Cutslopes	Fillslopes
% Observations w/short slope height	43	38
% Observations w/med. slope height	43	50
% Observations w /high slope height	14	12

	Cutslopes 1993	Cutslopes 1995	Fillslopes 1993	Fillslopes 1995
% Observations w/0-25% exposed soil	0	0	0	0
% Observations w/26-50 % exposed soil	0	12	0	14
% Observations w/51-75 % exposed soil	0	13	50	29
% Observations w/76-100 % exposed soil	100	75	50	57
% Observations w/Evidence of Erosion	100	100	100	100
Evidence of Erosion w/delivery to surface water	yes	yes	yes	yes
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	yes	yes	yes
BMP Effectiveness Ratings:	**Not Effective**		**Not Effective**	

COMMENTS:

The forest practices evaluated with this survey are cutslope and fillslope construction practices on a road segment draining to the crossing of a type 4 stream. The road surface consisted of native soils, without any crushed rock surfacing. Unlike the segment of road surveyed in Cutslope/Fillslope CF-01, this segment was relatively steep, with an average gradient of 11 %. After the harvest was completed in early 1994, water bars were installed and dry grass seed was applied to the road in an effort to stabilize the soils. The types of erosion documented on the cutslope, ditches, fillslope, and road surface ranged from minor ravel, sloughing, slumping, sheetwash erosion, and tension cracks to major gullies. Delivery of fine sediment to the type 4 stream was observed in minor amounts during the 1993 survey, associated with surface erosion at the culvert fill and sidecast ravel into the stream from a fillslope on a spur road that paralleled the stream; this was a very high fillslope and was located within 10 meters of the stream. The 1995 follow-up survey documented substantial amounts of sediment delivery to the surface water from severely eroded cutslopes, ditches, fillslopes and the road surface. Gully erosion on the fillslopes was associated with water bar discharges, and some of this fillslope erosion routed sediment to the stream. Volume measurements determined over 3 m^3 of sediment eroded and delivered from fillslope gullies. Gully erosion in one 10 meter section of ditch produced 1.5 m^3 of sediment, and it was estimated that mass erosion on cutslopes delivered over 20 m^3 of sediment to the direct entry ditch. As indicated by information on soil exposure presented above, the rate of revegetation was extremely slow, especially on the cutslopes, creating the potential for continued sediment delivery from this road segment.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey

Site: Muddy West	Treatment (Road Construction - Stream Crossing)		
Survey Dates: 7/93 & 8/94	Water Type: 4		
Survey #: SE-01A	Total reach length center line:		24 M
	Length of left bank:		29 M
	Length of right bank:		32 M
	Total Bank length:		60 M
	Year		
	1993	1994	
Total # eroding banks	0	6	
Total # Sampled	0	6	
Total length of eroding banks	0.0 M	19.1 M	
Total area of eroding banks	0.0 sq. m.	5.9 sq. m.	
% of bank length eroding:	0%	32%	
Cause of Bank Erosion:	Length of Eroding Bank:		
Wildlife	0	0 M	
Flowing Water	0	0.8 M	
Channel Destabilization	0	18.3 M	

Stream Bank Erosion Survey

Site: Muddy Control	Control		
Survey Dates: 7/93 & 8/94	Water Type: 4		
Survey #: SE-02	Total reach length center line:		51 M
	Length of left bank:		66 M
	Length of right bank:		65 M
	Total bank length:		131 M
	Year		
	1993	1994	
Total # eroding banks	0	0	
Total # Sampled	0	0	
Total length of eroding banks	0.0M	0.0 M	
Total area of eroding banks	0.0 sq. m.	0.0 sq. m.	
% of bank length eroding	0%	0%	
Cause of Bank Erosion:			
N/A			

Forest practices evaluated with this survey were stream crossing practices for new road construction. A culvert was installed immediately downstream of the treatment reach (the SE-01B treatment reach for evaluation of harvest practices is immediately upstream of the SE-01A reach affected by road construction.) The road crossing filled the lowermost 4 to 5 meters of the treatment reach with fill material and a culvert; that portion of the reach is excluded from this erosion analysis. A relict beaver dam located just upstream of the road crossing was destabilized between the pre-treatment and post-treatment surveys. Changes in the streambed elevation associated with culvert placement, and/or removal of channel roughness elements (*e.g.*, woody debris) just upstream of the culvert effectively changed the hydraulic gradient of this section of the study reach. The change apparently contributed to a localized increase in stream energy, and a subsequent increase in bank erosion and downcutting. Scour of banks occurred both up stream and downstream of the destabilized beaver dam which had been an important local channel control element. There was also a small isolated area of bank erosion attributed to scour by stream flows, but this was upstream of the area disturbed by the road crossing effects. The banks of the control reach remained stable over the monitoring period.

BMP Effectiveness Rating: NOT EFFECTIVE

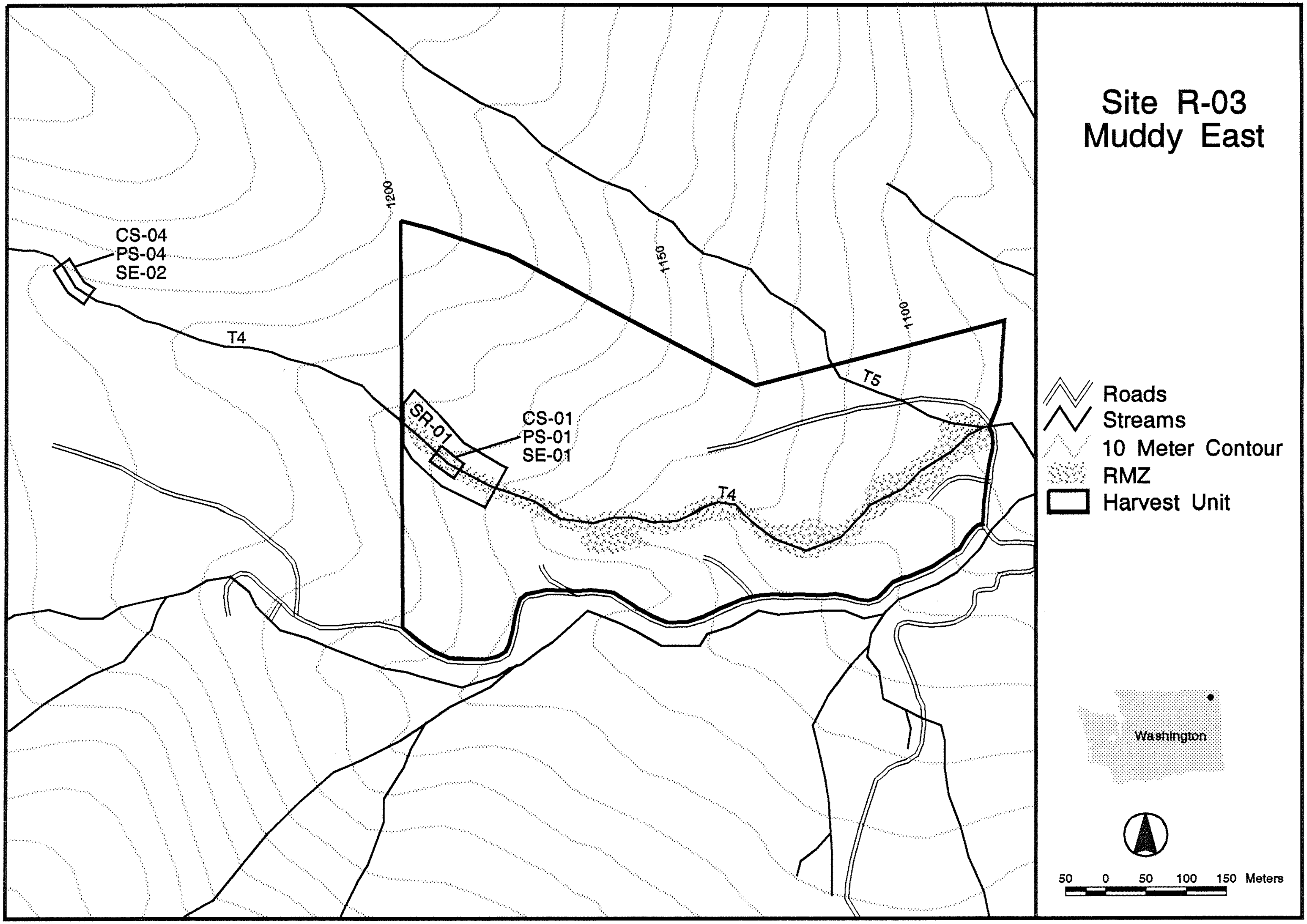
Site R-03: Muddy East

The Muddy East site is located just to the northeast of the Muddy West site, in northwest Pend Orielle County in the Northern Rockies physiographic region. Harvest practices were evaluated at this site. Muddy East is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the site is mapped as undifferentiated glacial drift deposits, which overlay granitic bedrock. Soils at the site are mapped as Aits loam (high precipitation), 15-25% slopes, with the 25-40% slope phase of the Aits loam occurring in the northeast corner of the unit. The 15-25% phase soils are rated as stable for disturbed slope stability, with a slight cutbank/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 cutbank/fill/sidecast hazard. The harvest BMP slope hazard category for the site is moderate, based on stream valley side slope gradients of 14% to 33% measured in the vicinity of the RMZ study reach.

The study stream at this site is a 1st order, Type 4 stream that is a tributary of Big Muddy Creek in the Pend Orielle River basin. The stream has a step-pool channel morphology, with an average active channel width of about 1 meter and an average gradient of 10% in the study reach.

Forest practices conducted at the Muddy East site include a 30 hectare partial cut harvest with 40% volume removal. Harvest was conducted using ground-based yarding methods. A RMZ was established on the Type 4 stream (although classified as a Type 4, the perennial stream was treated with a standard regulation Type 3 RMZ for the purposes of the CMER Wildlife-RMZ study). The width of the RMZ averaged 14 meters in the vicinity of the survey areas. Timber harvest was completed in January 1994.

Harvest BMPs evaluated at this site were the RMZ and adjacent ground-based harvest practices. One in-stream study reach was established on the Type 4 stream buffered by the RMZ. Channel condition, photo point, and stream bank erosion surveys were conducted on the RMZ treatment reach in July 1993 and August 1994. The control reach for these surveys is located at the "Muddy Control" site, upstream of the Muddy East harvest unit on the same stream. (Note: this is the same as one of the control reaches used for the Muddy West harvest evaluation.) Riparian amphibian surveys were conducted along the Type 4 stream and RMZ and at the Muddy Control site by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project. A sediment routing survey covering harvest areas on both sides of the stream was conducted along the upstream portion of the RMZ in September 1994.



Site R-03
Muddy East
Roads
Streams
10 Meter Contour
RMZ
Harvest Unit
Washington
50
0
50
100
150
Meters
CS-04
PS-04
SE-02
T4
1200
1150
1100
T5
SR-01
CS-01
PS-01
SE-01
T4

Harvest BMP Effectiveness Summary

Study Site: R-03: Muddy East - Partial cut harvest with RMZ

BMP Effectiveness Ratings

	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01	Effective					
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01/CS-04	Effective					
	Photo Point: PS-01/PS-04	Effective					
	Stream Bank Erosion: SE-01/SE-02	Effective					
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

Aspect 1 Case Narrative: Although major skid roads ran parallel to and within 15 to 30 meters of the stream, no erosion features attributed to timber falling or yarding were found to deliver sediment to the stream buffered with a RMZ within the survey area on this partial cut unit. Disturbed soils covered 15% of the survey area in the survey conducted 9 months following harvest. The only erosion features delivering sediment to the stream within the survey area were associated with two windthrown trees.

Aspect 2 Case Narrative: Channel condition, photo point, and stream bank erosion surveys did not show any in-stream impacts from timber harvest activities within the study reach. Both treatment and control reaches showed evidence of increases in the extent of fresh sediment deposits and mobilization of finer grains on the streambed. There was increased fine sediment deposition in pools accompanied by decreases in the extent of non-pool fines. Increased flow deflection onto stream banks was also observed in the treatment reach. Overall, the changes in stream channel condition were not great, with channel condition scores decreasing by 9-10% in treatment and control reaches over the monitoring period. The photo point surveys did not document any windthrow along either the RMZ study reach or the upstream control reach over the 13 month monitoring period. Increased bank erosion documented in the stream bank erosion surveys was not attributable to timber harvest activities.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Muddy East	Survey Date	9/15/94
Site Id #	R-03	Survey Id #	SR-01
Water Type	4	Months Since Harvest	9

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	900.0	75-100	787.5
2	skid trail	no	21.1	0-25	2.6
3	windthrow	no	2.8	75-100	2.5
4	yarding	no	682.0	75-100	596.8
5	windthrow	yes	2.2	75-100	1.9
6	windthrow	no	1.9	75-100	1.7
7	windthrow	yes	3.4	75-100	3.0
	TOTALS	2 delivered	1613.4		1396.0

Total Area of Ground Surveyed = 1.1 hectares

Total Length of Stream Bank Surveyed = 402 meters

Disturbed Soil per Hectare = 1466.7 m^2/ha.

Area Exposed Soil per Hectare = 1269.1 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 4.9 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 4.5 m^2/ha.

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0.0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0.0 m^2/ha.**

* Features that delivered but were not directly attributable to harvest activities, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	2	790.1	0.0	0
yarding	1	596.8	0.0	0
windthrow	4	9.1	4.9	100

NARRATIVE:

Forest practices evaluated at this site were partial-cut harvesting using ground-based yarding methods on both sides of a type 4 stream buffered with a standard regulation "type 3" RMZ. The RMZ, which averaged 14 meters in width and was not yarded across in the vicinity of the survey area, was effective at preventing direct sediment delivery to the type 4 stream.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Muddy East R-03

Treatment Survey ID#: CS-01 Water Type: 4
Control Survey ID#: CS-04 (@ Muddy Control Site) Water Type: 4

BMP(s) Evaluated: RMZ (Partial Cut Harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	55	7/27/93	61	6/1/93
Post-Treatment Survey #1:	50	8/25/94	55	8/24/94
Change from Pre-Treatment Score:	-5		-6	
Net Change (Control-Treatment):	+1			

BMP EFFECTIVENESS CALL: Effective

Case Narrative:
Treatment and control reaches are both on the same stream, and both have step-pool morphologies with average channel gradients of 10% and 8%, respectively. Little overall change in channel integrity or sediment deposition was noted in either study reach over the monitoring period. The change in score for the treatment reach is attributable to observations of increased flow deflection into banks, increased extent of fresh sediment deposits, and increased fines in pools. These negative changes in the channel condition score were offset by a decrease in the extent of non-pool fines and a shift in dominant particle size from fines to gravels. The changes in score for the control reach reflected increased fines in pools, increased bed mobility/brightness, and a shift in dominant particle size from gravels and cobbles to fines. These decreases in channel condition score in the control reach were offset by observations of slightly reduced bank erosion and decreased non-pool fines. Within the treatment reach it was noted that fine sediment within the channel had been mobilized and fresh deposits were obvious at sediment storage/channel roughness elements. It was also noted that banks and woody debris elements appeared very stable, that larger grains (cobbles) had obvious algal growth or clinging vegetation, and that there was no evidence of sediment delivery to the study reach or direct channel disturbance attributable to timber falling, yarding, or nearby skid trails.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey (Treatment)

Site:	Muddy East	Treatment	
Survey Dates:	7/93 & 8/94	Water Type: 4	
Survey #:	SE-01	Total Reach Length center line 36.2M	
		Length of Left bank: 49.0M	
		Length of Right Bank: 48.0M	
		Total Bank Length: 97.0M	

	Year 1993	Year 1994
Total # eroding banks	4	8
Total # Sampled	4	8
Total length of eroding banks	2.3M	7.0M
Total area of eroding banks	0.5 sq. m.	2.1 sq. m.
% of bank length eroding:	2.4%	7.2%

Cause of Bank Erosion:	Length of Eroding Bank:	
Wildlife	0.3M	1.8M
Flowing Water	2.0M	5.2M

Stream Bank Erosion Survey (Control)

Site:	Muddy Control	Control	
Survey Dates:	7/93 & 8/94	Water Type: 4	
Survey #:	SE-02	Total reach length center line:	50.6M
		Length of left bank:	66.0M
		Length of right bank:	65.0M
		Total bank length:	131.0M

	Year 1993	Year 1994
Total # eroding banks	0	0
Total # Sampled	0	0
Total length of eroding banks	0.0M	0.0M
Total area of eroding banks	0.0 sq. m.	0.0 sq. m.
% of bank length eroding	0%	0%

Cause of Bank Erosion:
N/A

The treatment reach at Muddy East was located on a type 4 stream that was buffered with a standard "type 3" RMZ within a partial cut harvest unit. The increase in erosion documented between 1993 and 1994 was not attributable to the effects of timber harvest activities. The banks of the control reach remained very stable in 1993 and 1994. The banks of the control reach were very soft/erodible in areas not protected by boulder and bedrock.

BMP Effectiveness Rating: EFFECTIVE

In-Stream Photo Point Survey Comparison Summary

Site: Muddy East   Survey Dates: July 1993 and August 1994

Indicators of in-channel changes	Control PS-04 Yes	Control PS-04 No	Treatment PS-01 Yes	Treatment PS-01 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X		X
4. Is there evidence of increased deposition or storage of fine or course sediment?		X	X	
5. Are there changes in woody debris?				
Increase in large WD?		X		X
Increase in small WD?	X		X	
Decrease in WD?	X			X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X		X

Summary:
The treatment study reach was virtually unchanged between 1993 and 1994.
The flow in 1994 for the treatment was greater than that seen in either the control or at the Muddy West site.

BMP Effectiveness Call: Effective

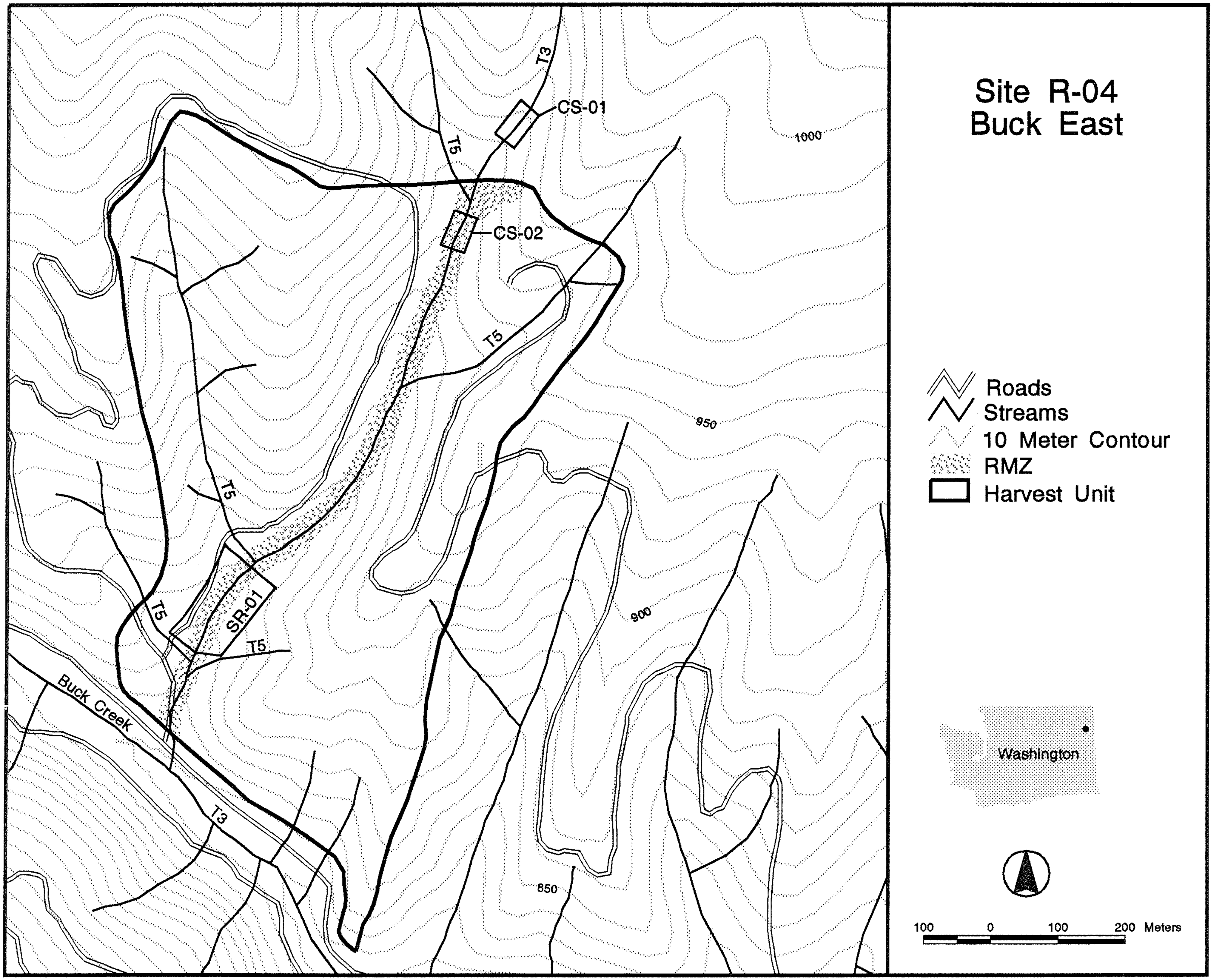
Site R-04: Buck East

Buck East is harvest practice evaluation site located in southwest Pend Orielle County in the Northern Rockies physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the area is mapped as Phillips Lake Granodiorite, a medium to coarse-grained granitic rock of late Cretaceous age. Soils at the study site are primarily Moscow silt loam, 0-25% slopes, with the Skanid-Rock outcrop complex, 0-40% slopes, occurring on the ridges at the upstream end of the unit. Both soil mapping units are rated as stable for disturbed slope stability, with a moderate cutbank/fill/sidecast hazard and a medium erosion potential. Based on stream valley side slope gradients of 28% to 40% measured in the vicinity of the study reach, the harvest BMP slope hazard category for the site is moderate.

The study stream at this site is a 1st order, Type 3 stream that is a tributary of Buck Creek in the Little Spokane River basin. Although classified as a Type 4 stream on the FPA and DNR Water Type map, salmonid use was observed during field surveys in the upper control reach of this stream. The stream has a step-pool channel morphology, with an average active channel width of about 2 meters and an average gradient of 10% in the downstream study reach. There are also several zero order, Type 5 streams within the harvest unit.

Forest practices conducted at the Buck East site include a 49 hectare partial cut harvest with 50% volume removal, using ground-based yarding methods. A RMZ was established on the Type 3 study stream. Although officially classified as a Type 4, the stream was treated with a RMZ for the purposes of the CMER Wildlife-RMZ study. The RMZ at Buck East was designed as an experimental treatment, meaning that it is intended to provide enhanced riparian zone protection above the minimum requirements of a standard regulation RMZ. The width of the RMZ averaged 18 meters in the sediment routing survey area located in the downstream portion of the harvest unit. Timber harvest was completed in early March of 1994.

Harvest BMPs evaluated at this site include the RMZ along the Type 3 stream and adjacent ground-based harvest practices. In-stream study reaches were established on the Type 3 stream that is buffered by the RMZ. The treatment reach is located in the upstream portion of the RMZ, and the control reach is located on the same stream upstream of the harvest unit boundary. Channel condition surveys were conducted on both study reaches in June 1993 and September 1994. Riparian amphibian surveys were conducted along the Type 3 stream and RMZ by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project. Sediment routing surveys covering harvest areas on both sides of the stream were conducted along the downstream portion of the RMZ in September 1994 and June 1995. General observations were also made of a skid trail constructed along the edge of the RMZ in the central portion of the harvest unit.



Site R-04
Buck East
Roads
Streams
10 Meter Contour
RMZ
Harvest Unit
Washington
100
0
100
200 Meters
CS-01
CS-02
SR-01
T3
T5
T5
T5
T5
T5
T3
Buck Creek
1000
950
900
850

Harvest BMP Effectiveness Summary

Study Site:	R-04: Buck East - Partial cut harvest with RMZ						
		BMP Effectiveness Ratings					
	Survey Employed	Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.		WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060
	Sediment Routing: SR-01	Effective					
Case Narrative:	Although major skid trails ran parallel to the stream, no erosion features attributable to timber harvest activities were found to be chronic sources of sediment to the stream buffered with a RMZ within the sediment routing survey area. However, several skid trail features were observed to be delivering sediment to the type 3 stream during the initial survey conducted 6 months following harvest. This temporary sediment delivery was associated with drainage from several skid trail spurs that concentrated surface runoff at a skid trail that paralleled the stream. The concentrated drainage eroded cut and fill slopes and was subsequently routed to the stream via numerous small (<10 cm wide) channelized drainage paths across the RMZ. No channelized flowpaths or other evidence of routing from this skid trail was observed in the follow-up survey conducted 15 months following harvest. At another area in the harvest unit, upstream of the sediment routing survey area, a skid trail was constructed so close to the stream that sidecast from its fill slopes raveled into the type 3 stream. A 20 meter length of the stream was affected by sediment deposition from sidecast ravel and erosion, and although not included in the sediment routing survey results, this is more likely to be a chronic source of sediment to the stream.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-02/CS-01	Effective					
Case Narrative:	Relatively minor changes were observed in the surveys conducted in both the RMZ treatment reach and the upstream control reach, with channel condition scores decreasing by 9-10% over the 15 month monitoring period. No in-stream impacts associated with timber harvest activities were evident in the RMZ study reach. Decreases in the extent of fresh sediment deposits, increased fines in pools, and destabilization of sediment storage elements associated with small woody debris were observed in both the treatment and control reaches.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Buck East	Survey Date	9/16/94
Site Id #	R-04	Survey Id #	SR-01
Water Type	3	Months Since Harvest	6

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	550.5	25-50	206.4
2	skid trail	no	191.4	0-25	23.9
3	skid trail	no	16.5	25-50	6.2
4	skid trail	yes	690.0	50-75	431.3
5	skid trail	yes	36.6	75-100	32.0
6	skid trail	yes	62.3	0-25	7.8
7	skid trail	yes	52.5	25-50	19.7
8	skid trail	yes	91.8	75-100	80.3
9	skid trail	yes	36.0	50-75	22.5
10	skid trail	yes	69.0	25-50	25.9
11	skid trail	no	195.6	50-75	122.3
12	skid trail	no	230.6	25-50	86.5
13	skid trail	no	50.2	25-50	18.8
14	windthrow	no	2.4	50-75	1.5
15	windthrow	yes	6.8	0-25	0.9
	TOTALS	8 delivered	2282.2		1086.0

Total Area of Ground Surveyed = 1.6 hectares

Total Length of Stream Bank Surveyed = 332 meters

Disturbed Soil per Hectare = 1426.4 m^2/ha.

Area Exposed Soil per Hectare = 678.8 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 620.4 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 387.8 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 619.5 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 387.2 m^2/ha**

* Features that delivered but were not directly attributable to current harvest activities, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	13	1083.6	619.5	99.9
windthrow	2	2.4	0.9	0.1

NARRATIVE:

Forest practices evaluated with this survey were partial cut harvesting using ground-based yarding methods on both sides of a type 3 stream buffered with a RMZ. Sediment delivery to the stream was associated with drainage from several skid trail spurs that concentrated surface runoff at a major skid trail that paralleled the stream just outside the RMZ. There was evidence that the concentrated drainage eroded cut and fill slopes and was subsequently routed to the stream via numerous small (< 10 cm wide) channelized drainage paths across the RMZ.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Buck East	Survey Date	6/23/95
Site Id #	R-04	Survey Id #	SR-01
Water Type	4	Months Since Harvest	15

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	550.5	0-25	68.8
2	skid trail	no	191.4	0-25	23.9
3	skid trail	no	16.5	0-25	2.1
4	skid trail	no	690.0	25-50	258.8
5	skid trail	no	36.6	50-75	22.9
6	skid trail	no	62.3	0-25	7.8
7	skid trail	no	52.5	0-25	6.6
8	skid trail	no	91.8	75-100	80.3
9	skid trail	no	36.0	25-50	13.5
10	skid trail	no	69.0	25-50	25.9
11	skid trail	no	195.6	25-50	73.4
12	skid trail	no	230.6	0-25	28.8
13	skid trail	no	50.2	25-50	18.8
14	windthrow	no	2.4	25-50	0.9
15	windthrow	no	6.8	25-50	2.6
	TOTALS	0 delivered	2282.2		635.1

Total Area of Ground Surveyed = 1.6 hectares

Total Length of Stream Bank Surveyed = 332 meters

Disturbed Soil per Hectare = 1426.4 m^2/ha.

Area Exposed Soil per Hectare = 396.9 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* Features that delivered but were not directly attributable to current harvest activities, such as windthrow, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	13	631.6	0.0	n/a
windthrow	2	3.5	0.0	n/a

NARRATIVE:

Forest practices evaluated with this survey were partial cut harvesting using ground-based yarding methods on both sides of a type 3 stream buffered with a RMZ. Although major skid trails ran parallel to the stream, no erosion features attributable to timber harvest activities were found to be chronic sources of sediment to the stream buffered with a RMZ, within the sediment routing survey area. The average width of the RMZ in the survey area was 18 meters on both sides of the stream, and it was not yarded across in the vicinity of the survey. There was no evidence of continued sediment delivery from several skid trail features that were observed to be delivering sediment to the type 3 stream during the initial survey conducted 6 months following harvest. This short-term sediment delivery was associated with drainage from several skid trail spurs that concentrated surface runoff at a major skid trail that paralleled the stream. The concentrated drainage was subsequently routed to the stream via numerous small (< 10 cm wide) channelized drainage paths across the RMZ. However, no channelized flowpaths or other evidence of routing from this skid trail was observed in this follow-up survey conducted 15 months following harvest.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Buck East R-04

Treatment Survey ID#: CS-02 — Water Type: 3
Control Survey ID#: CS-01 — Water Type: 3

BMP(s) Evaluated: RMZ (Partial Cut Harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	58	6/2/93	56	6/2/93
Post-Treatment Survey #1:	52	9/16/94	51	9/16/94
Change from Pre-Treatment Score:	-6		-5	
Net Change (Control-Treatment):	-1			

BMP EFFECTIVENESS CALL: Effective

Case Narrative:

Both treatment and control reaches were on the same stream, which had a step-pool morphology with a channel gradient of 10% to 12%. The control reach was located just upstream of the harvest unit. There was no evidence of timber harvesting effects within the RMZ study reach. Changes in channel condition score over the monitoring period were attributable primarily to increases in the extent of fines in pools and destabilization of sediment storage elements associated with small WD, and these changes were observed in both treatment and control reaches. Increased flow deflection onto banks was also observed in the treatment reach.

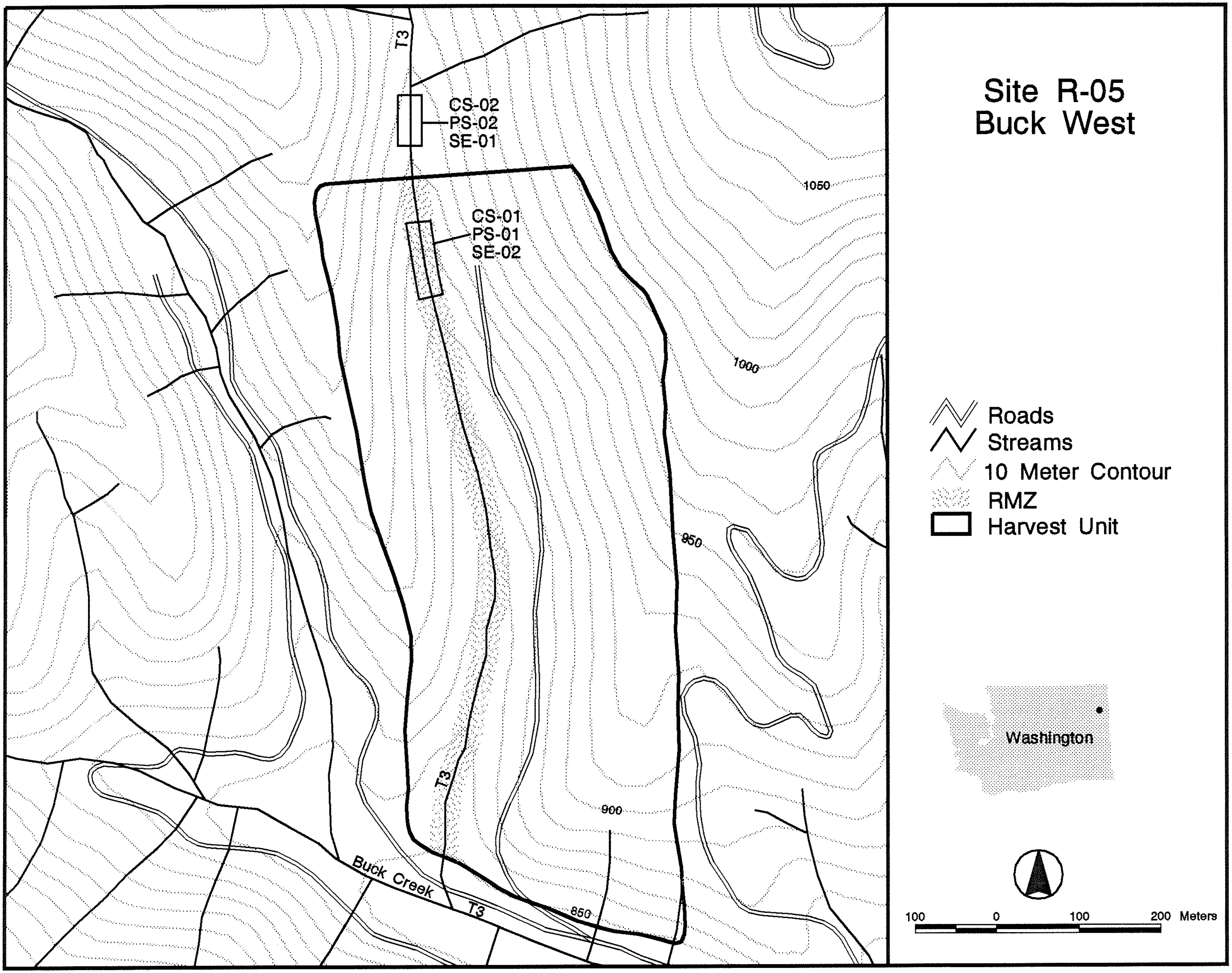
Site R-05: Buck West

Buck West is a harvest practice evaluation site located just to the west of the Buck East study site in southwest Pend Orielle County in the Northern Rockies physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the site is mapped as Phillips Lake Granodiorite. Soils at the study site are classified as 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 ridges. The soil hazard ratings for the 40-65% slope phases are unstable for disturbed slope stability, with a severe cutbank/fill/sidecast hazard and a high erosion potential. The 0-25% and 0-40% slope phases are rated as stable for disturbed slope stability, with a moderate cutbank/fill/sidecast hazard and a medium erosion potential. The harvest BMP slope hazard category for the site is high, based on stream valley side slope gradients measured in the vicinity of the study reach, which range from 10% to 44%.

The study stream on this unit is a 1st order, Type 3 stream that is a tributary to Buck Creek, in the Little Spokane River basin. Although classified as a Type 4 stream on the FPA and DNR Water Type map, salmonid use was observed in this stream during field surveys. The stream has a step-pool channel morphology, with an average active channel width of 2.5 meters and an average gradient of 7% within the RMZ study reach.

Forest practices conducted at this site include a 29 hectare partial cut harvest with 60% volume removal, using ground-based yarding methods. A RMZ was established on the Type 3 study stream. Although officially classified as a Type 4, the stream was treated with a standard regulation Type 3 RMZ for the purposes of the CMER Wildlife-RMZ study. The width of the RMZ averaged 14 meters in the vicinity of the in-stream survey reach located in the upstream portion of the harvest unit. Timber harvest was completed in December of 1993.

BMPs evaluated at the Buck West site were the RMZ along the Type 3 stream and adjacent ground-based harvest practices. Two in-stream study reaches were established on the Type 3 stream that is buffered by the RMZ: a treatment reach located in the upstream portion of the RMZ, and a control reach located on the same stream upstream of the harvest unit boundary. Channel condition, photo point, and stream bank erosion surveys were conducted on both study reaches in June and August of 1993, and June and August of 1994. Riparian amphibian surveys were conducted along the Type 3 stream and RMZ by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project.



Site R-05
Buck West
T3
CS-02
PS-02
SE-01
CS-01
PS-01
SE-02
1050
1000
950
900
850
T3
Buck Creek
T3
Roads
Streams
10 Meter Contour
RMZ
Harvest Unit
Washington
100
0
100
200 Meters

Harvest BMP Effectiveness Summary

Study Site: R-05: Buck West - Partial cut harvest with RMZ

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050): Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters): Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)): Ground-based Yarding WAC 222-30-070	Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	While no separate erosion/delivery surveys were conducted to evaluate harvest practices at the Buck West site, it was noted during in-stream surveys that there was no evidence of direct delivery of sediment from harvest practices in the vicinity of the RMZ study reach. The upslope edges of the RMZ were roughly defined by two parallel skid trails constructed on both sides of the stream. Some trees were harvested from within the RMZ but entry by ground-based yarding equipment was very limited.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01/CS-02	Effective					
	Photo Point: PS-01/PS-02	Effective					
	Stream Bank Erosion: SE-02/SE-01	Effective					
Case Narrative:	The RMZ treatment reach was virtually unchanged, comparing conditions from before to after the harvest. The control reach experienced an increase in stream bank erosion and fine sediment deposition, associated with a major elk trail that crossed through the control reach. Photo point surveys did not show any new windthrown trees crossing the channel over the 12 month monitoring period in either the 87 meter RMZ reach or the 63 meter control reach.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Buck West R-05

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: CS-02 Water Type: 3

BMP(s) Evaluated: RMZ (Partial Cut Harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	62	6/2/93	59	6/2/93
Post-Treatment Survey #1:	65	6/27/94	46	6/27/94
Change from Pre-Treatment Score:	+3		-13	
Net Change (Control-Treatment):	+16			

BMP EFFECTIVENESS CALL: Effective

Case Narrative:

Both treatment and control reaches were on the same stream, which had a step-pool morphology with a channel gradient of 7% to 8%. The control reach was located just upstream of the harvest unit. There was no evidence of timber harvesting effects within the RMZ study reach. The treatment reach was virtually unchanged over the monitoring period, while there was substantial channel disturbance by elk activity within the control reach, leading to destabilization of the lower stream banks accompanied by fine sediment deposition.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey

Site: Buck West — Treatment
Survey Dates: 8/93 & 6/94 — Water Type: 3
Survey #: SE-02 — Total reach length center line: 86.5M
Length of left bank: 84.6M
Length of right bank: 86.1M
Total bank length:170.7M

	Year 1993	Year 1994
Total # eroding banks	1	1
Total # Sampled	1	1
Total length of eroding banks	0.3M	2.2M
Total area of eroding banks	0.1 sq. m.	1.4 sq. m.
% of bank length eroding	0.2%	1.3%

Cause of Bank Erosion:	Length of Eroding Banks:	
Flowing water	0.3M	Bank stabilized
Pre-existing windthrow	0	2.2M

Stream Bank Erosion Survey

Site: Buck West — Control
Survey Dates: 8/93 & 6/94 — Water Type: 3
Survey #: SE-01 — Total reach length center line: 64.1M
Length of left bank: 76.1M
Length of right bank: 73.2M
Total Bank length: 149.3M

	Year 1993	Year 1994
Total # eroding banks	6	4
Total # Sampled	6	4
Total length of eroding banks	4.3M	7.4M
Total area of eroding banks	1.3 sq. m.	2.0 sq. m.
% of bank length eroding:	3%	5%

Cause of Bank Erosion:	Length of Eroding Banks:	
Wildlife Trail	4.3M	7.4M
Flowing Water	0	0

The forest practices evaluated at this site were partial-cut harvest using ground-based equipment and a variable width RMZ along the type 3 stream. The upslope edge of the RMZ was roughly defined by parallel skid trails constructed on both sides of the stream. Several trees were cut from within the RMZ, but equipment entry was very limited. The bank erosion documented within the treatment reach was not attributable to timber harvest activities (erosion of the rootwad of a pre-existing windthrow was re-activated by streamflow scour), and was less than that documented within the control reach.

BMP Effectiveness Rating: EFFECTIVE

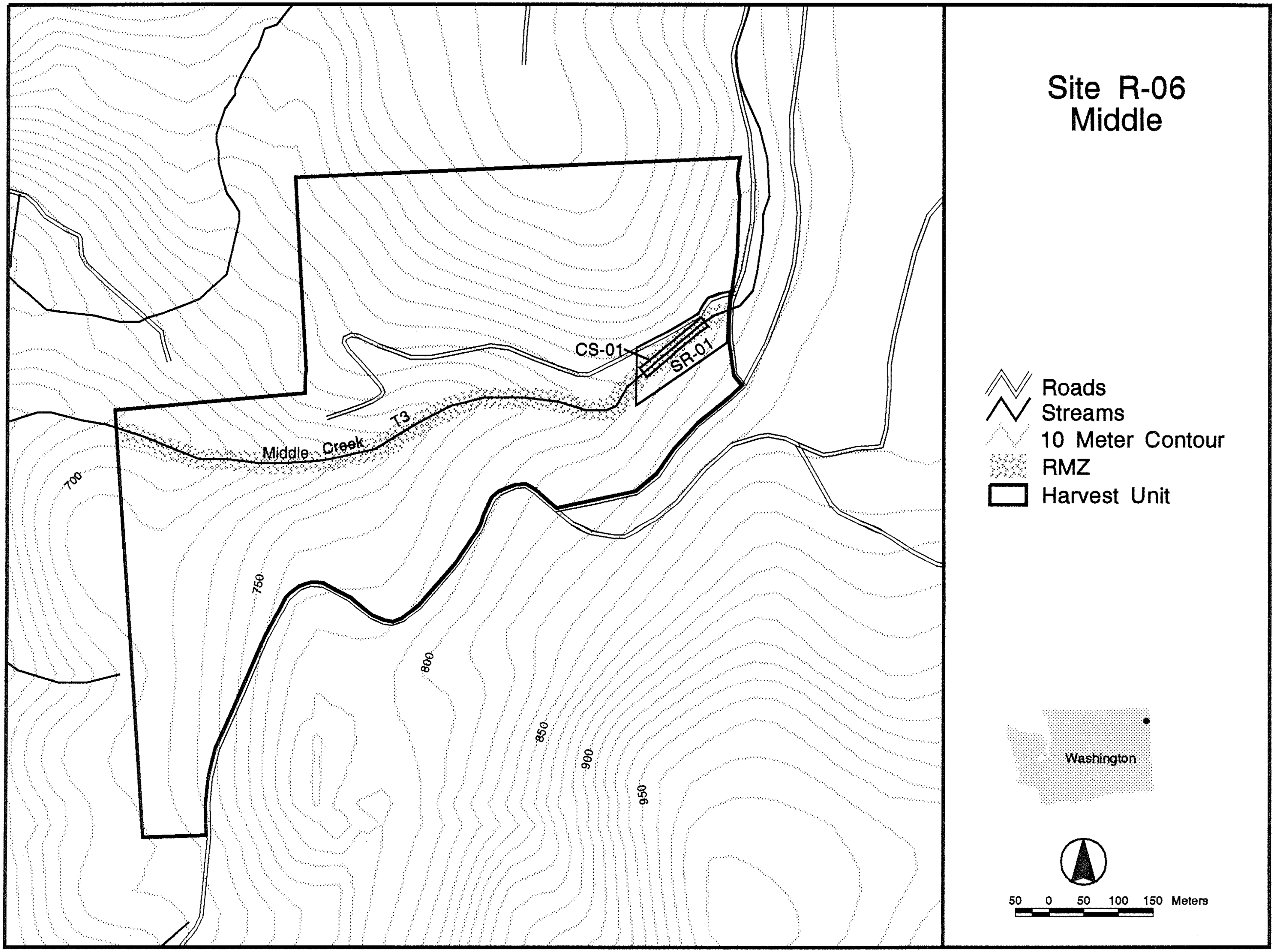
Site R-06: Middle

The Middle site is a harvest practice evaluation located in central Pend Orielle County in the Northern Rockies physiographic region. This site is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the site is mapped as glaciolacustrine deposits, undifferentiated glacial drift deposits, and Mill Creek Granodiorite. Soils are primarily Inkler-Rock outcrop complex, 40-65% slopes; Scotia fine sandy loam, 15-25% slopes; and Sacheen loamy fine sand, 15-25% slopes. The Inkler-Rock outcrop soils are rated as unstable for disturbed slope stability, with the other soils on the unit rated as stable. All three soil mapping units are rated as moderate for cutbank/fill/sidecast hazard and medium for erosion potential. The harvest BMP slope hazard category for the site is high, with stream valley side slope gradients ranging from 56% to 65% in the vicinity of the study reach.

The study stream at this site is a 2nd order, Type 3 stream named Middle Creek, which is a tributary of the Pend Orielle River. The stream has a cascade/step-pool channel morphology, with an average active channel width of 4 meters and an average gradient of 9% within the RMZ study reach.

Forest practices conducted at this site include a 61 hectare partial cut harvest with 70% volume removal, using ground-based yarding methods. A RMZ was established along Middle Creek. The width of the RMZ averaged 13 meters in the sediment routing survey area. Timber harvest was completed in February 1994.

BMPs evaluated at the site were the RMZ along Middle Creek and adjacent ground-based harvest practices. One in-stream study reach was established on Middle Creek. Channel condition surveys were conducted in June 1993 and September 1994 for a before/after comparison of the RMZ treatment reach. A suitable paired control reach was not available for this evaluation because the character of the stream channel was quite different upstream of the harvest unit. Riparian amphibian surveys were conducted along the Type 3 stream and RMZ by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project. A sediment routing survey covering harvest areas on both sides of the stream was conducted along the upstream portion of the RMZ in September 1994.



Site R-06
Middle
Roads
Streams
10 Meter Contour
RMZ
Harvest Unit
Washington
50 0 50 100 150 Meters
CS-01
SR-01
T3
Middle Creek
700
750
800
850
900
950

Harvest BMP Effectiveness Summary

Study Site: R-06: Middle - Partial cut harvest with RMZ

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050)		Harvest with no buffers (Type 4 and/or 5 Waters)		Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5))	
		Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding	Ground-based Yarding	Cable Yarding
		WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060	WAC 222-30-070	WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Sediment Routing: SR-01	Effective					
Case Narrative:	The sediment routing survey evaluated a partial cut harvest area on both sides of a type 3 stream buffered by a RMZ, with harvest conducted using ground-based yarding methods. The survey was conducted 7 months following harvest. Disturbed soils covered only about 2% of the survey area, and the erosion features identified consisted of skid trails, yarding disturbance, and one tree falling scar. None of the erosion features identified delivered sediment to the stream or were located within 10 meters of the stream. Trees were harvested on relatively steep valley side slopes within the RMZ, including some trees directionally felled very near the stream bank, but there was no yarding across the stream. Minor disturbances associated with windthrow or individual tree falling divots were not surveyed as erosion features because there was either no soil exposure or they did not meet the minimum size criteria. The lack of soil disturbance associated with tree falling and yarding is attributed to the fact that the harvest was conducted during winter on frozen and/or snow-covered ground. On one side of the stream, timber was yarded up the steep valley side slopes using a jammer (truck-mounted winch and cable). Just downstream of the survey area, mass wasting erosion was observed on the steep valley walls, but this was un-related to harvest activities.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-01	Effective					
Case Narrative:	No disturbance of the stream channel, banks, or lower valley walls was observed within the RMZ study reach, although some trees were felled very near the stream bank. There was no paired control reach available for comparison, but before/after channel condition surveys in the treatment reach showed a slight increase in channel condition score over the 15 month monitoring period.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Middle	Survey Date	9/13/94
Site Id #	R-06	Survey Id #	SR-01
Water Type	3	Months Since Harvest	7

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail	no	9.1	25-50	3.4
2	skid trail	no	48.6	25-50	18.2
3	skid trail	no	36.4	0-25	4.6
4	skid trail	no	121.9	50-75	76.2
5	falling	no	9.6	0-25	1.2
	TOTALS	0 delivered	225.6		103.6

Total Area of Ground Surveyed = 1.4 hectares

Total Length of Stream Bank Surveyed = 312 meters

Disturbed Soil per Hectare = 161.1 m^2/ha

Area Exposed Soil per Hectare = 74.0 m^2/ha.

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 0 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
skid trail	4	102.4	0.0	n/a
falling	1	1.2	0.0	n/a

NARRATIVE:

Forest practices evaluated with this survey were partial cut harvesting using ground-based yarding methods on both sides of a type 3 stream buffered with a RMZ. The RMZ, which averaged 13 meters in width on both sides of the stream and was not yarded across in the vicinity of the survey area, was effective at preventing sediment delivery to the stream. Some trees were harvested on relatively steep valley side slopes within the RMZ, including some trees directionally felled very near the stream bank, but no erosion features associated with falling or yarding activity were identified within 10 meters of the stream. Disturbed soils covered only about 2% of the survey area, and the erosion features identified consisted of skid trails (some of the skid trail features included yarding disturbance adjacent to the trail), and one tree falling scar. Minor disturbances associated with windthrow or individual tree falling divots were not identified as erosion features because there was either no soil exposure or they did not meet the minimum size criteria. The lack of soil disturbance associated with tree falling and yarding is attributed to the fact that the harvest was conducted during winter on frozen and/or snow-covered ground.

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Middle R-06

Treatment Survey ID#: CS-01 Water Type: 3
Control Survey ID#: none Water Type:

BMP(s) Evaluated: Partial Cut Harvest (ground-based yarding) with RMZ.

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	42	6/2/93		
Post-Treatment Survey #1:	45	9/13/94	(No paired Control Reach was available for Middle)	
Change from Pre-Treatment Score:	+3			
Net Change (Control-Treatment):	n/a			
Post-Treatment Survey #2:	none			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
Partial cut harvest was conducted on both sides of and within the RMZ, including steep valley wall areas. A jammer was apparently used to yard up the valley walls in conjunction with directional felling. No disturbance of the stream channel, banks, or lower valley walls was observed within the study reach. The lack of disturbance is attributed to the fact that harvest activities were conducted during the winter when the ground was frozen and/or snow covered.

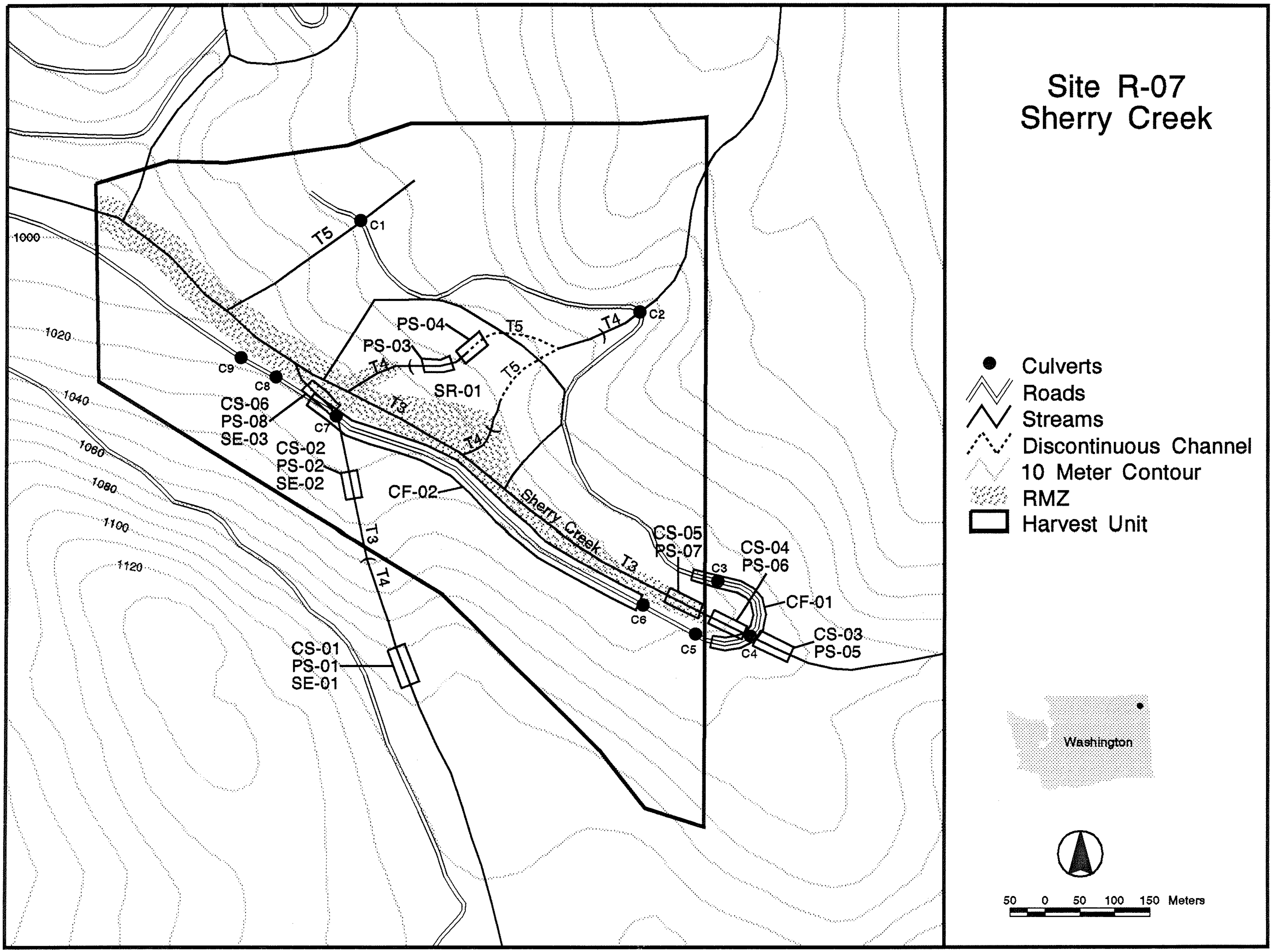
Site R-07: Sherry Creek

Sherry Creek is a harvest and road construction evaluation site located in eastern Stevens County in the Northern Rockies physiographic region. Sherry Creek is also part of the CMER Wildlife-RMZ research project. The surface geology of the site is mapped as 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, 0-40% slopes. The soil hazard ratings for the 40-65% slope phases are unstable for disturbed slope stability, with severe cutbank/fill/sidecast hazards and medium to high erosion potential. The 0-10% and 0-40% slope phases are rated as stable for disturbed slope stability, with slight to moderate cutbank/fill/sidecast hazards and low to medium erosion potential. The harvest BMP slope hazard category is moderate along the RMZ and high in the vicinity of an un-buffered stream, based on stream valley side slope gradients. The road construction BMP slope hazard category for the site is moderate.

The study streams at this site include Sherry Creek, a 2nd order, Type 3 stream that is a tributary of the Little Pend Orielle River, and several of its tributaries. The upper reach of Sherry Creek within the harvest unit was classified as Type 4 on the FPA, but salmonid use was observed during field surveys in the upper study reaches. Within the study reaches, Sherry Creek has a step-pool morphology, with an average active channel width of 2-3 meters and average gradient of 5-6%. In the harvest area on the south side of Sherry Creek is a 1st order, Type 3 stream, which has a step-pool morphology, with an average active channel width of 1-1.5 meters and a gradient of 5-6%. This tributary was classified as a Type 4, but salmonid use was observed during field surveys in two study reaches. Within the harvest area on the north side of Sherry Creek are a zero order Type 5 stream (not typed on the FPA), and a 1st order, Type 4 stream that has two Type 5 distributary channels, which change to Type 4 streams in the RMZ.

Forest practices conducted at this site include a 42 hectare partial cut harvest with 40% volume removal, using ground-based yarding methods, and approximately 2.1 km of road construction, of which a portion involved reconstruction along an existing route. A RMZ was established along Sherry Creek. The width of the RMZ averaged 27 meters in the sediment routing survey area on the north side of Sherry Creek, and 22 meters in the vicinity of the in-stream survey reach in the upstream portion of the harvest unit. Road construction was completed in September 1993. Timber harvest was completed in January 1994.

BMPs evaluated at this site include the RMZ along Sherry Creek and adjacent ground-based harvest practices, ground-based harvest in the vicinity of the Sherry Creek tributaries without stream buffers, and road construction practices, including water crossings (culverts), road design (relief culverts), and road construction techniques (cut and fill slopes). Three in-stream study reaches were established on Sherry Creek, including an RMZ treatment reach, a treatment reach downstream of the road crossing but upstream of the harvest unit, and a control reach upstream of the road. Channel condition and photo point surveys were conducted on the Sherry Creek study reaches in August 1993, June 1994, and June 1995. In addition, riparian amphibian surveys were conducted along Sherry Creek and the RMZ by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project. Surveys evaluating harvest without stream buffers include channel condition, photo point, and stream bank erosion surveys conducted in June and July of 1993, and June 1994 on the Type 3 tributary on the south side of Sherry Creek, with the control reach located on the same stream upstream of the harvest unit boundary. Photo point surveys were also used for a before/after comparison of conditions in an un-buffered Type 5 stream on the north side of Sherry Creek. Sediment routing surveys covering a harvest area along the RMZ on the north side of Sherry Creek, and an adjacent area where harvest occurred in the vicinity of Type 5 streams without stream buffers, were conducted in September 1994 and June 1995. Surveys to evaluate road construction BMPs include cutbank/fillslope surveys of two road drainage segments, conducted in November 1993, June 1994, and June 1995. Culvert condition surveys covering 1.9 km. of the road were conducted in November 1993 and June 1994, with follow-up observations of stream crossing culverts in June 1995. In addition to in-stream surveys evaluating road effects on Sherry Creek (mentioned above), channel condition, photo point, and stream bank erosion surveys were conducted downstream of the road crossing on the Type 3 tributary.



Site R-07
Sherry Creek
Culverts
Roads
Streams
Discontinuous Channel
10 Meter Contour
RMZ
Harvest Unit
Washington
50 0 50 100 150 Meters
T5
C1
C2
T4
T5
T5
PS-04
PS-03
T4
SR-01
T3
T4
C9
C8
C7
CS-06
PS-08
SE-03
CS-02
PS-02
SE-02
CF-02
Sherry Creek
T3
T3
T4
CS-01
PS-01
SE-01
CS-05
PS-07
C3
CS-04
PS-06
CF-01
C6
C5
C4
CS-03
PS-05
1000
1020
1040
1060
1080
1100
1120

Harvest BMP Effectiveness Summary

Study Site: R-07: Sherry Creek - Partial cut harvest, with RMZ and harvest without stream buffers.

	Survey Employed	**BMP Effectiveness Ratings** Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050) Ground-based Yarding WAC 222-30-070	Harvest w/ RMZ & Streambank Integrity BMPs Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters) Ground-based Yarding WAC 222-30-070	Harvest with no buffers (Type 4 and/or 5 Waters) Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) Ground-based Yarding WAC 222-30-070	Harvest with RLTAs (Type 4 and/or 5 Waters) Cable Yarding WAC 222-30-060
ASPECT 1:							
Effectiveness in terms of	Sediment Routing:						
chronic erosion with delivery	SR-01BU	Effective					
to surface waters.	SR-01NB			Not Effective			

Case Narrative: The sediment routing survey area included 1.7 hectares of harvest area draining to Sherry Creek (SR-01BU survey), which was buffered by a RMZ, and 1.3 hectares of harvest area on the north side of Sherry Creek where harvest occurred in the vicinity of type 4 and 5 streams without stream buffers (SR-01NB survey). The RMZ was not crossed by timber yarding routes, although a limited number of trees were harvested from the RMZ. At the time of the initial survey conducted 9 months following harvest, disturbed soils covered 2% of the SR-01BU survey area, with erosion features attributed to skid trails and other yarding activity and disturbance by wildlife/livestock. However, the only sediment delivery to Sherry Creek was associated with wildlife/livestock erosion within the RMZ. Soil disturbance associated with skid trails and other timber falling and yarding activity covered 6% of the SR-01NB survey area, and 4 of 11 harvest erosion features delivered sediment to the type 5 streams within the survey area. By the time of the follow-up survey conducted 18 months following harvest, disturbed soils covered less than 1% of the SR-01BU survey area, and 3% of the SR-01NB survey area. Several of the skid trails and yarding features had revegetated and/or were no longer delivering sediment to streams. One major skid trail crossing was continuing to deliver substantial amounts of sediment to an un-buffered type 5 stream. The RMZ was effective at preventing direct sediment delivery to Sherry Creek from harvest erosion features. Indirect delivery to Sherry Creek via the un-buffered tributary crossed by the skid trail is likely.

	Survey Employed	Harvest w/ RMZ: Ground-based Yarding	Harvest w/ RMZ: Cable Yarding	No buffers: Ground-based Yarding	No buffers: Cable Yarding	RLTAs: Ground-based Yarding	RLTAs: Cable Yarding
	Channel Condition:						
ASPECT 2:	CS-02/CS-01			Effective			
Effectiveness in terms of	CS-05/CS-03	Effective					
local stream impacts and	Photo Point:						
response (sedimentation,	PS-02/PS-01			Effective			
physical integrity, and/or	PS-03 & PS-04			Effective			
biological integrity).	PS-07/PS-05	Effective					
	Stream Bank Erosion:						
	SE-02/SE-01			Effective			

Case Narrative: Channel condition and photo point surveys in the RMZ study reach did not show adverse effects associated with timber harvesting. The study reach showed some effects from a road crossing located about 140 meters upstream. Photo point surveys in the RMZ study reach did not document any windthrow over the 18-month post harvest monitoring period. In-stream surveys evaluating the tributary on the south side of Sherry Creek that was not buffered (mapped as a type 4, but actually a type 3 - salmonids were observed within the reach) showed very little change in stream channel conditions associated with timber harvest activities. Stream bank erosion surveys in this unbuffered stream showed a slight decrease in erosion over the monitoring period, while the upstream control reach showed a slight increase. Photo point surveys documented one windthrown tree over the 11 month monitoring period in the 35 meter treatment reach, and 6 trees down across the channel in the 60 meter control reach over the same period. It was noted that within the study reach there was no direct physical disturbance of the stream channel from harvesting activities, although trees were harvested from adjacent stream valley side slopes. The ground-based harvest was conducted during the winter on frozen and/or snow covered ground, and this apparently minimized disturbance of soils and springs/wetlands in the vicinity of the stream. Photo point surveys (PS-03 and PS-04) on an un-buffered type 5 tributary on the north side of Sherry Creek documented 2 windthrown trees down along 100 meters of the stream over a 10 month monitoring period. Other than localized disturbance and short-term sediment delivery at a skid trail crossing, no in-stream impacts were evident. Streamside trees harvested along the study reaches were yarded away from the stream. Extensive in-stream sediment deposition was observed in another type 5 tributary on the north side of Sherry Creek, associated with a major skid trail crossing where temporary fill was used. Deposition surveys conducted in conjunction with the sediment routing survey measured 1 cubic meter of in-stream deposits that covered the streambed substrate for at least 20 meters downstream of the crossing.

		Harvest w/ RMZ: Ground-based Yarding	Harvest w/ RMZ: Cable Yarding	No buffers: Ground-based Yarding	No buffers: Cable Yarding	RLTAs: Ground-based Yarding	RLTAs: Cable Yarding
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE		PARTIALLY EFFECTIVE			

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sherry Cr.	Survey Date(s)	9/14/94
Site Id #	R-07	Survey Id #	SR-01BU
Water Type	3, 4	Months Since Harvest	9

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
9	skid trail	no	117.6	75-100	102.6
10	skid trail	no	62.0	50-75	38.8
11	skid trail	no	37.4	25-50	14.0
12	yarding	no	3.1	50-75	1.9
13	wildlife/livestock	yes	17.6	0-25	2.2
14	wildlife/livestock	no	9.4	25-50	3.5
15	skid trail	no	94.6	0-25	11.8
16	wildlife/livestock	yes	2.0	0-25	0.3
17	wildlife/livestock	yes	2.4	0-25	0.3
	TOTALS	3 delivered	346.1		175.4

Total Area of Ground Surveyed = 1.7 hectares

Total Length of Stream Bank Surveyed = 433 meters

Disturbed Soil per Hectare = 203.6 m^2/hectare

Exposed Soil per Hectare = 103.2 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 2.8 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 1.7 m^2/ha

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* Features that delivered but were not directly attributable to current harvest activities, such as wildlife/livestock activities, were excluded from these calculations.

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	4	167.2	0.0	0
Yarding	1	1.9	0.0	0
Wildlife/Livestock	4	6.3	2.8	100

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Sherry Creek, which was buffered by a RMZ, and the lowermost segments of two type 4 tributaries, where they flow through the Sherry Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were partial cut harvesting using ground-based yarding methods in the vicinity of a type 3 water (Sherry Creek) buffered by a RMZ. The RMZ was not crossed by timber yarding routes, although a limited number of trees were harvested from the RMZ. At the time of this initial survey, conducted 9 months following harvest, disturbed soils covered 2% of the SR-01BU survey area, with erosion features attributed to skid trails and other yarding activity and disturbance by wildlife/livestock. However, the only sediment delivery to Sherry Creek was a small amount associated with wildlife/livestock disturbance within the RMZ, and located within 10 meters of Sherry Creek. The RMZ, which averaged 27 meters in width in the vicinity of the survey area and extended upstream on the type 4 tributaries, was effective at preventing direct sediment delivery or stream channel disturbance in Sherry Creek from erosion associated with harvesting activities. Indirect sediment delivery to Sherry Creek via an un-buffered tributary crossed by a skid trail is likely (refer to SR-01NB survey).

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sherry Cr.	Survey Date	6/21/95
Site Id #	R-07	Survey Id #	SR-01BU
Water Type	3, 4	Months Since Harvest	18

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
9	skid trail	no	56.0	0-25	7.0
10	skid trail	no	40.1	50-75	25.1
11	skid trail	no longer eroding - revegetated			
12	yarding	not re-surveyed			
13	wildlife/livestock	not re-surveyed			
14	wildlife/livestock	not re-surveyed			
15	skid trail	not re-surveyed			
16	wildlife/livestock	not re-surveyed			
17	wildlife/livestock	not re-surveyed			
	TOTALS	0 delivered	96.1		32.1

Total Area of Ground Surveyed = 1.2 hectares

Total Length of Stream Bank Surveyed = 293 meters

Disturbed Soil per Hectare = 80.1 m^2/hectare

Exposed Soil per Hectare = 26.8 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = Not Determined

Exposed Soil from All Erosion Features that Delivered per Hectare = Not Determined

*** Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 0 m^2**

*** Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 0 m^2/ha**

* Features that delivered but were not directly attributable to current harvest activities, such as wildlife/livestock activities, were excluded from these calculations.

NARRATIVE:

The SR-01BU survey includes portions of the SR-01 survey area that drain to Sherry Creek, which was buffered by a RMZ, and the lowermost segments of two type 4 tributaries, where they flow through the Sherry Creek RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were partial cut harvesting using ground-based yarding methods in the vicinity of a type 3 water (Sherry Creek) buffered by a RMZ. The RMZ was not crossed by timber yarding routes, although a limited number of trees were harvested from the RMZ. This 1995 follow-up survey focused on re-surveying those erosion features that delivered to streams in 1994 and were attributable to timber harvest activities, in order to determine BMP effectiveness (*i.e.*, to determine whether chronic sediment delivery occurred). Therefore, a reduced survey area was covered in 1995, and the four erosion features attributed to wildlife/livestock activity (three of which delivered in 1994), as well as one yarding and one skid trail feature with very little potential to deliver sediment, were not re-surveyed in 1995. In the initial survey, nine erosion features attributed to skid trails and other yarding activity and disturbance by wildlife/livestock were identified. However, the only sediment delivery to Sherry Creek was a small amount associated with wildlife/livestock disturbance within the RMZ, and located within 10 meters of Sherry Creek. At the time of this follow-up survey, conducted 18 months following harvest, disturbed soils covered less than 1% of the SR-01BU survey area. Some skid trail erosion features had fully or partially revegetated. The RMZ, which averaged 27 meters in width in the vicinity of the survey area and extended upstream on the type 4 tributaries, was effective at preventing direct sediment delivery to Sherry Creek from erosion associated with harvesting activities. Indirect sediment delivery to Sherry Creek via an un-buffered tributary crossed by a skid trail is likely (refer to SR-01NB survey).

BMP EFFECTIVENESS RATING:

RMZ (Ground-based Yarding): EFFECTIVE

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sherry Cr.	Survey Date	9/14/94
Site Id #	R-07	Survey Id #	SR-01NB
Water Type	4, 5	Months Since Harvest	9

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail (Xing)	yes	22.1	25-50	8.3
2	windthrow	no	1.9	25-50	0.7
3	skid trail	no	100.0	0-25	12.5
4	skid trail	no	233.2	50-75	145.8
5	skid trail	no	15.8	50-75	9.9
6	yarding	no	2.6	50-75	1.6
7	skid trail	no	2.7	0-25	0.3
8	skid trail	no	41.4	25-50	15.5
18	skid trail (Xing)	yes	145.6	75-100	127.4
19	skid trail	yes	69.2	75-100	60.6
20	falling	yes	9.7	25-50	3.6
21	skid trail	no	168.2	50-75	105.1
	TOTALS	4 delivered	812.4		491.3

Total Area of Ground Surveyed = 1.3 hectares

Total Length of Stream Bank Surveyed = 390 meters

Disturbed Soil per Hectare = 624.9 m^2/hectare

Exposed Soil per Hectare = 377.9 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = 199.9 m^2

Exposed Soil from All Erosion Features that Delivered per Hectare = 153.8 m^2/ha

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 199.9 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 153.8 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	9	485.4	196.3	98.2
Yarding	1	1.6	0	0
Falling	1	3.6	3.6	1.8
Windthrow	1	0.7	0	0

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the un-buffered type 4/5 tributaries to Sherry Creek, upstream of where they enter the RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were partial cut harvesting using ground-based yarding methods in the vicinity of un-buffered type 4 and 5 streams. Soil disturbance associated with skid trails and other timber falling and yarding activity covered 6% of the SR-01NB survey area, and 4 of 11 harvest erosion features delivered sediment to the type 5 streams within the survey area. Sediment delivery was primarily attributable to skid trail crossings of Type 5 waters. In one case (feature 18), fill material was temporarily placed to cross the stream, resulting in extensive disturbance of the stream channel and upper banks, with substantial amount of sediment delivery to the type 5 stream (became type 4 approx. 14 meters downstream of crossing). Some of this sediment was observed as in-stream deposits covering the streambed downstream of the crossing area. Delivery to Sherry Creek via this tributary is likely.

SEDIMENT ROUTING SURVEY DATA SUMMARY

Study Site	Sherry Cr.	Survey Date	6/21/95
Site Id #	R-07	Survey Id #	SR-01NB
Water Type	4, 5	Months Since Harvest	18

FEATURE #	FEATURE TYPE	DELIVERED TO WATER	SURFACE AREA DISTURBED SOIL (m^2)	% EXPOSED SOIL AREA	SURFACE AREA EXPOSED SOIL (m^2)
1	skid trail (Xing)	no	13.4	50-75	8.4
2	windthrow	not re-surveyed			
3	skid trail	no longer eroding - revegetated			
4	skid trail	no longer eroding - revegetated			
5	skid trail	no longer eroding - revegetated			
6	yarding	no longer eroding - revegetated			
7	skid trail	no longer eroding - revegetated			
8	skid trail	no longer eroding - revegetated			
18	skid trail (Xing)	yes	108.6	50-75	67.9
19	skid trail	no	137.8	50-75	86.1
20	falling	no	8.5	0-25	1.1
21	skid trail	no	119.7	25-50	44.9
	TOTALS	1 delivered	388.0		208.4

Total Area of Ground Surveyed = 1.3 hectares

Total Length of Stream Bank Surveyed = 390 meters

Disturbed Soil per Hectare = 298.5 m^2/hectare

Exposed Soil per Hectare = 160.3 m^2/hectare

Total Surface Area Exposed Soil from All Erosion Features that Delivered to Water = Not Determined

Exposed Soil from All Erosion Features that Delivered per Hectare = Not Determined

Total Surface Area Exposed Soil from Harvest Erosion Features that Delivered to Water = 67.9 m^2

Exposed Soil from Harvest Erosion Features that Delivered per Hectare = 52.2 m^2/ha

CAUSE/EFFECT INFORMATION:

Cause of Erosion	Number of Features	Surface Area of Exposed Soil (m^2)	Exposed Soil from Features that Delivered (m^2)	% of Total Delivery (based on area of exposed soil)
Skid Trail	4	207.3	67.9	100
Yarding	1	no longer eroding - revegetated		
Falling	1	1.1	0.0	0
Windthrow	1	not resurveyed - did not deliver in 1994		

NARRATIVE:

The SR-01NB survey includes portions of the SR-01 survey area that drain to the un-buffered type 4/5 tributaries to Sherry Creek, upstream of where they enter the RMZ. The feature numbers refer to the field survey photo map, which included both buffered and un-buffered portions of the survey area. The forest practices evaluated were partial cut harvesting using ground-based yarding methods in the vicinity of un-buffered type 4 and 5 streams. This 1995 follow-up survey focused on re-surveying those erosion features that delivered to streams in 1994 and were attributable to timber harvest activities, in order to determine BMP effectiveness (*i.e.*, to determine whether chronic sediment delivery occurred). Therefore, a windthrow feature identified in 1994 was not re-surveyed in 1995. At the time of this follow-up survey, conducted 18 months following harvest, disturbed soils covered about 3% of the SR-01NB survey area. Several of the skid trails and yarding features had revegetated and/or were no longer delivering sediment to streams. One major skid trail crossing, where temporary fill had been placed in the stream, was continuing to deliver substantial amounts of sediment to an un-buffered type 5 stream. Measurements of in-stream deposits found 1 cubic meter of fine sediment covering the streambed for at least 20 meters downstream of the crossing area. Indirect delivery to Sherry Creek via the un-buffered tributary crossed by the skid trail is likely.

BMP EFFECTIVENESS RATING:

Ground-based Yarding (Partial Cut Harvest) without Stream Buffers: NOT EFFECTIVE

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Sherry R-07

Treatment Survey ID#: CS-02 Water Type: 3
Control Survey ID#: CS-01 Water Type: 4

BMP(s) Evaluated: Partial Cut Harvest without Buffer

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	59	6/3/93	62	6/3/93
Post-Treatment Survey #1:	56	6/28/94	59	6/28/94
Change from Pre-Treatment Score:	-3		-3	
Net Change (Control-Treatment):	0			
Post-Treatment Survey #2:	none			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:

Very little change was documented in either the treatment or control reach. There was no direct disturbance of the stream channel from harvesting activities along or within the treatment reach. Trees were harvested from adjacent valley walls and hillslopes, but not immediately adjacent to the stream within this reach; the closest fresh stump observed was approximately 5 meters from the streambank. The harvest was conducted during winter, on frozen and/or snow covered ground, and this apparently minimized ground disturbance and disturbance of springs and wetlands in the vicinity of the stream. Although the treatment reach was mapped as a type 4 stream, we observed juvenile salmonids in the reach during the field surveys.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey

Site: Sherry Creek — Treatment (Partial Cut w/ no buffer)
Survey Dates: 7/93 & 6/94 — Water Type: 3
Survey #: SE-02 — Total reach length center line: 33.3M
Length of left bank: 41.5M
Length of right bank: 39.5M
Total bank length: 81.0M

	Year 1993	Year 1994
Total # eroding banks	3	3
Total # Sampled	3	3
Total length of eroding banks	2.0M	1.8M
Total area of eroding banks	0.9 sq. m.	0.9 sq. m.
% of bank length eroding:	2.5%	2.2%

Cause of Bank Erosion:	Length of Eroding Bank: 1993	1994
Wildlife	0.8M	1.4M
Unknown	1.2M	0.4M

Stream Bank Erosion Survey

Site: Sherry Creek — Control
Survey Dates: 7/93 & 6/94 — Water Type: 4
Survey # SE-01 — Total reach length center line: 56.0M
Length of left bank: 62.0M
Length of right bank: 59.0M
Total bank length: 121.0M

	Year 1993	Year 1994
Total # eroding banks	4	5
Total # Sampled	4	5
Total length of eroding banks	2.3M	2.7M
Total area of eroding banks	3.1 sq. m.	1.0 sq. m.
% of bank length eroding	1.9%	2.2%

Cause of Bank Erosion:	Length of Eroding Bank: 1993	1994
Wildlife	1.0M	1.1M
Unknown	1.3M	0
Flowing Water	0	1.6M

Forest practices evaluated were partial-cut harvesting using ground-based equipment without stream buffers along a small Type 3 stream (was classified as type 4 on the FPA, but salmonid use was observed during field surveys in two different study reaches). Despite the lack of a stream buffer, there was no evidence of disturbance of either upper or lower stream banks by timber falling, yarding, or skidding in the vicinity of the study reach. A very slight decrease in the extent of bank erosion was observed in the treatment reach and a slight increase was observed in the control reach over the course of the monitoring period.

BMP Effectiveness Rating: EFFECTIVE

In-Stream Photo Point Survey Summary

Site: Sherry Creek R-07 Survey dates: 8/26/93 & 6/29/94
Survey Id: PS-03 & PS-04 Treatment Reaches (no control comparison)
Water Type: 5 Reach Length: 44 m (PS-03), 56m (PS-04)

Indicators of in-channel changes	Yes	No	Photo/Field Note References 1992	1993	1994	1995
1. Is there evidence of increased streambank erosion and /or physical disturbance of banks?		X				
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X				
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?		X				
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X				
5. Are there changes in woody debris?						
Increase in large WD?	X*					
Increase in small WD		X				
Decrease in WD?		X				
*1 new windthrow in PS-03 reach and 1 in PS-04 reach.						
6. Is there evidence of changes in aquatic plants due to scouring or other disturbance?		x				

Summary:

These surveys were used for a before-after comparison of changes associated with partial cut harvesting without stream buffers. Both reaches are downstream of a skid trail crossing. Some trees were felled very near or at the stream banks. Apparently they were felled away from the stream. No in-stream disturbance is apparent in the photo comparisons. There is no evidence of sediment routing below the skid trail crossing. The lack of soil disturbance is attributed to winter harvest over frozen and/or snow covered ground.

BMP Effectiveness Rating: Not Effective

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Sherry R-07

Treatment Survey ID#: CS-05 Water Type: 3
Control Survey ID#: CS-03 Water Type: 3

BMP(s) Evaluated: RMZ (Partial Cut Harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	68	8/26/93	65	8/26/93
Post-Treatment Survey #1:	55	6/28/94	61	6/28/94
Change from Pre-Treatment Score:	-13		-4	
Net Change (Control-Treatment):	-9			
Post-Treatment Survey #2:	58	6/21/95	56	6/19/95
Change from Pre-Treatment Score:	-10		-9	
Net Change (Control-Treatment):	-1			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
The net decrease in the treatment reach score is attributable primarily to slight to moderate increases in fresh sediment deposits, deposition of fines in pools, and bed mobility. In addition to the scores, comments on the survey forms documented the following noticeable differences between the treatment and control reaches: more rooted aquatic vegetation in the control, brighter substrate (less algal staining) in the treatment, and a greater amount of fresh deposits in the treatment. Also, floodplain and side channel deposits of very fine, ash-like sediments were observed along the treatment reach. The overall morphology and substrate character of the reaches is indicative of a moderate to high potential to store fine sediment deposits within the channel as well as on the floodplain and side channel areas. Stream banks and wet floodplain areas are highly susceptible to physical disturbance. The introduction of fresh sediment to the treatment reach is most likely attributable to the crossing of the stream by a new road, which is approximately 140 meters upstream. The road also parallels the treatment reach outside of the RMZ. No direct effects (i.e. physical disturbances) of timber harvesting were noted in the survey.

Study Site: R-07: Sherry Creek - New Road Construction

	Survey Employed	Culvert BMPs: Stream Xings WAC 222-24-040	Culvert BMPs: Relief WAC 222-24-025	Road Construction BMPs (WAC 222-24-030): Cutslopes	Road Construction BMPs (WAC 222-24-030): Fillslopes
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	Culvert Condition:				
	CC-01	Not Effective	Partially Effective		
	Cutbank/Fillslope:				
	CF-01			Not Effective	Effective
	CF-02			Effective	Effective

Case Narrative: The total length of new road construction surveyed in the culvert condition surveys was 1,858 meters, which included 9 culverts. 612 meters of this road length was outsloped, with the remainder draining via ditches to relief outfalls or stream crossings. One of five relief culverts delivered sediment to Sherry Creek within the first year following road construction, leading to a partially effective call for road drainage BMPs. Ground water interception with flowing water in the ditch was observed in the drainage segment of the relief culvert that delivered, with sediment transport through the RMZ and a distance of 11 meters between the outfall and stream. Sediment transport distances downslope of the other relief outfalls were 1 meter or less. Erosion of culvert fills at the four stream crossings was continuing at severe levels 9 months following road construction, with an increasing trend in erosion over the monitoring period, and gully erosion was observed at three of the four crossings. Follow-up observations in June 1995 (21 months following construction) confirmed that sediment delivery from culvert fill erosion was continuing at the two type 3 stream crossings. Armoring of culvert fills was poor to none at most of the culverts, and revegetation practices were either not effective or not employed at the culvert fills. In-stream deposition of eroded material was observed, covering the streambed substrate for a distance of 7 to 33 meters downstream of the crossings. Three of the four stream crossing culverts had outfalls hanging above the streambed at elevations of 0.2 to 0.5 meters. Cutslope erosion continued at moderate to severe levels due to the highly erodible soils and a lack of adequate revegetation practices (dry grass seeding was not effective at stabilizing road cuts). At one of the two drainage segments where cutslope practices were evaluated (CF-01 segment), cutslopes were still over 75% exposed 21 months following road construction, resulting in chronic sediment delivery via sediment transport in ditches draining to the crossing of Sherry Creek. Types of erosion observed in this segment included mass erosion and gully erosion on the cutslope, which was up to 7 meters high in some sections. Despite chronic erosion in the CF-02 drainage segment, there was very little evidence of surface flow in the ditch at the approach to the stream crossing, and no evidence of sediment delivery via the ditch to the type 3 stream. This drainage segment had relatively short cutslopes, and the predominant erosion processes appeared to be freeze/thaw and dry ravel; gullying and mass erosion was negligible on this segment. The most important factors in preventing sediment delivery in the CF-02 segment were the topographic and soil conditions of the site; the road flattened as it approached the crossing, thus facilitating infiltration of ditch flows in the extremely porous soils and sediment deposition and storage in the ditch. Fillslope practices are rated effective because delivery to streams of material eroded from fillslopes was limited to the immediate vicinity of the culvert fills. Although some sections of fillslopes that were up to 15 meters high came within several meters of Sherry Creek, monitoring of sediment plumes showed a maximum sediment transport distance of less than 3 meters for fillslope erosion.

	Survey Employed	Stream Xings	Relief	Cutslopes	Fillslopes
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition:				
	CS-04/CS-03	Effective		Effective	Effective
	CS-06/CS-01	Effective		Effective	Effective
	Photo Point:				
	PS-06/PS-05	Not Effective		Not Effective	Effective
	PS-08/PS-01	Effective		Effective	Effective
	Stream Bank Erosion:				
	SE-03/SE-01	Effective		Effective	Effective

Case Narrative: The channel condition and photo point surveys in the Sherry Creek study reach below the road crossing reflect increases in stream bank erosion, fine and course sediment deposition, and streambed mobility, as compared to the upstream control reach. Sediment deposition within this reach is attributed to a combination of culvert fill and cutslope erosion. Although the channel condition score in the CS-04 treatment reach decreased by 23% over the monitoring period, the net change in points did not exceed the 10 point threshold, and the channel condition survey results are rated effective. The channel condition survey in the CS-06 study reach below the crossing of the type 3 tributary to Sherry Creek showed increased sediment deposition attributed to construction phase erosion at the road crossing. The stream bank erosion surveys conducted on the same study reach showed some increase in bank erosion, but this was attributed to disturbance by wildlife or cattle.

	Stream Xings	Relief	Cutslopes	Fillslopes
OVERALL SITE BMP EFFECTIVENESS RATING:	NOT EFFECTIVE	PARTIALLY EFFECTIVE	PARTIALLY EFFECTIVE	EFFECTIVE

Sherry Creek Culvert Condition Survey Results

Site: R-07: Sherry Creek
Culvert Condition Survey CC-01
Survey Dates: 11/93 & 6/94, w/ follow-up observations 6/95
Date of construction: 9/93

Site BMP Effectiveness Rating:

Stream X-ing: Not Effective
Relief: Partially Effective

Culvert # and Type	Point of Observation	Extent of Erosion Survey Year		Culvert Spacing/ (Drainage Distance)	Trend in Erosion	Continuing Erosion (Y/N)	Channelized or Overland Flow Sediment Transport	Delivery to surface water from culvert	Effectiveness Call (Yes or No)
		1993	1994						
C1, T-5 x-ing	Inflow	Slight	Severe	73m	Increase	Y		Yes, Type 5	No
	Outflow	Slight	Severe	(71m)	Increase	Y			
C2,T-4 x-ing.	Inflow	Slight	Severe	500m	Increase	Y		Yes, Type 4	No
	Outflow	Slight	Severe	(176m)	Increase	Y			
C3, Relief	Inflow	Slight	Severe	384m	Increase	Y		No	Yes
	Outflow	Slight	Severe	(69m)	Increase	Y	No		
C4,T-3 x-ing	Inflow	Slight	Severe	131m	Increase	Y		Yes, Type 3	No
	Outflow	Moderate	Severe	(158m)	Increase	Y			
C5, Relief	Inflow	Slight	Severe	83m	Increase	Y	Yes,	No	Yes
	Outflow	Moderate	Severe	(48m)	Increase	Y	1m+ overland		
C6, Relief	Inflow	Slight	Moderate	109m	Increase	Y	Yes,	No	Yes
	Outflow	Slight	Severe	(96m)	Increase	Y	1m+ overland		
C7, T-3 x-ing	Inflow	Slight	Severe	410m	Increase	Y		Yes, Type 4	No
	Outflow	Slight	Severe	(446m)	Increase	Y			
C8,Relief	Inflow	Slight	Severe	96m	Increase	Y	Yes,	Yes, Type 3	No
	Outflow	Slight	Severe	(56m)	Increase	Y	Channelized 11m		
C9, Relief	Inflow	Moderate	Moderate	72m	Constant	Y		No	Yes
	Outflow	Slight	Moderate	(72m)	Increase	Y			

Comments/Notes Summary:

The total length of road surveyed was 1,858 meters, with an average spacing between culverts of 206 meters. However, the average drainage distance is 132 meters, because 412 meters of road between culverts 1 and 2, and 200 meters between C2 and C3 were outsloped. The average road gradient was 3.5 %, and it ranged from 0% to 7%. The hillslope gradient averaged 16% and 30 % in two drainage segments accounting for 605 meters of the road alignment, where it ranged from 8% to 52%. Very little erosion was observed at culvert fills in 1993, probably due to the age of the road--road construction was completed in September of 1993 and the 1993 survey was conducted in November, before any significant hydrologic events. By the 1994 survey, only 3 of the 18 "extent of erosion" calls were moderate, the other 15 were severe. Erosion of culvert fills at the four stream crossings was continuing at severe levels 9 months following road construction, with an increasing trend in erosion over the monitoring period, and gully erosion was observed at three of the four crossings. Sediment delivery from the culvert fill erosion was evident at all 4 stream crossings. Three of the four stream crossing culverts had outfalls hanging above the streambed at elevations of 0.2 to 0.5 meters. At C1, fresh road sediment was observed as in-stream deposits extending to 33 meters downstream of the crossing. At C2,the culvert fill on the outfall side was gullying and slumping into the stream, with unambiguous sediment deposition observed to at least 11 meters downstream. The type 3 stream crossings at C4 and C7 were inspected in June 1995, and chronic sediment delivery from culvert fill erosion was confirmed. Field observations of salmonid use indicated that the stream crossed by culvert 7 is a type 3, not a type 4 water as classified on the FPA. One of five relief culverts delivered sediment to Sherry Creek within the first year following road construction, leading to a partially effective call for road drainage BMPs. Ground water interception with flowing water in the ditch was observed in the drainage segment of the relief culvert that delivered, with sediment transport through the RMZ and a distance of 11 meters between the outfall and stream. Sediment transport distances downslope of the other relief outfalls did not exceed about 1 meter. Of the 18 armoring effectiveness calls made at the inflow and outflow of each of the 9 culverts, only 2 were rated fair, 14 were rated poor, and 2 were rated "none". Dry grass seeding may have been employed but was not effective at stabilizing culvert fills, and natural re-vegetation of the exposed soil was slow and patchy, probably due to low nutrient levels in the weathered granitic soils and/or low soil moisture. Armoring the culvert fills with rock would have been the most effective way to prevent chronic erosion at this site.

CUTBANK/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Sherry Creek
Survey Id #'s	CF-01
Survey Dates	11/3/93, 6/28/94, 6/21/95
Water Type	3
Construction Date:	9/1993

Length of Road Draining to Stream:	158 meters (plus additional 69m along fillslope)	Range Road Gradient	0-6 %
		Average Road Gradient	3 %
		Range Hillslope Gradient	8-52 %
		Average Hillslope Gradient	30 %
		Range Cutslope Gradient	5-58 deg.
		Average Cutslope Gradient	33 deg.

	Cutslopes	Fillslopes
% Observations w/short slope height	71	55
% Observations w/med. slope height	0	27
% Observations w/high slope height	29	18

	1993	1994	1995	1993	1994	1995
% Observations w/0-25% exposed soil	0	0	0	0	0	10
% Observations w/26-50 % exposed soil	0	0	14	0	0	27
% Observations w/51-75 % exposed soil	0	0	14	0	0	36
% Observations w/76-100 % exposed soil	100	100	72	100	100	27
% Observations w/Evidence of Erosion	100	100	100	100	100	100

(In 1993, the only type of erosion noted on both the cut and fillslopes was "slight surface" erosion. The types of erosion observed in the 1994 and 1995 surveys ranged from surface erosion to gullying, and slumping,.)

Evidence Erosion w/delivery to surface water	no	yes	yes		Only at culvert fill	
Gullying and/or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	yes	yes	no	yes	yes
BMP Effectiveness Rating:	**Not Effective**				**Effective**	

COMMENTS:

The forest practices evaluated with this survey are new road construction across a type 3 stream (Sherry Creek). The forest upstream of the road crossing was outside of the timber harvest unit boundary while that below the crossing was selectively cut using ground-based equipment. The first survey in 1993, was conducted approximately two months after the road construction was completed. Prior to the initial (1993) survey, there did not appear to have been any significant hydrologic events since the completion of construction, and the types of erosion noted during the survey were limited to slight surface erosion. Substantial erosion of the cut and fillslopes were documented in both the 1994 and 1995 surveys, with the types of erosion observed ranging from surface erosion to gullying and localized mass wasting. Stake flags placed at the toe of the fillslope in several areas within several meters of Sherry Creek during the 1993 survey were monitored during the 1994 and 1995 surveys. Lacking concentrated flow, the investigators noted the maximum downslope movement of eroded fillslope sediment to be around 2.5 meters, and did not observe sediment delivery to the stream from the fillslope except at the immediate area of the culvert fill. Dry grass seeding was not successful at controlling erosion of cutslopes, ditches, and the road surface at this site. Sediment delivery to Sherry Creek the stream from the cutslope erosion via the direct-entry ditchline was documented in 1994 and 1995, resulting in a not effective call for cutslope BMPs using in-sloped road construction. In 1995, about 110 meters of ditchline had evidence of flow with continued delivery of cutslope and road surface erosion to Sherry Creek. The upper 50 meters of the drainage segment did not have evidence of ditch flow or sediment routing in the ditch.

CUTSLOPE/FILLSLOPE SURVEY RESULTS SUMMARY

SITE:	Sherry Cr.
Survey Id #'s	CF-02
Survey Dates	11/4/93, 6/29/94, w/ follow-up observations in June 1995
Water Type	3 (mis-classified as type 4)

Length of Road Draining to Stream: 447 m.

Range Road Gradient	0-7 %
Average Road Gradient	5 %
Range Hillslope Gradient	5-32 %
Average Hillslope Gradient	16 %
Range Cutslope Gradient	30-60 deg.
Average Cutslope Gradient	43 deg.

	Cutslopes		Fillslopes	
% Observations w/short slope height	80		70	
% Observations w/med. slope height	20		30	
% Observations w/high slope height	0		0	
	1993	1994	1993	1994
% Observations w/0-25% exposed	0	0	0	0
% Observations w/26-50 % exposed	0	11	0	44
% Observations w/51-75 % exposed	0	0	0	33
% Observations w/76-100 % exposed	100	89	100	23
% Observations w/Evidence Erosion	80	100	30	100
Evidence Erosion w/delivery to surface water	no	no	no	no
Gullying or Mass Erosion on Cuts, Fills, Ditches, or Road Surface	no	no	no	no
BMP Effectiveness Ratings:	**Effective**		**Effective**	

COMMENTS:
Forest practices evaluated with this survey are new road construction across a type 3 tributary to Sherry Creek. While construction techniques and soil stabilization BMPs employed on this road drainage segment did not differ significantly from other road construction sites evaluated in the region, factors related to road location and local topography and soil characteristics of the site perhaps, prevented chronic sediment delivery at the stream crossing, despite chronic erosion of cutslopes in the drainage segment. There was very little residual evidence of flowing water on the road surface or within the ditch draining to the stream crossing. This is attributed to a combination of extremely porous soils and the relatively flat topography of the site. The latter factor resulted in relatively short cutslopes along the drainage segment. The dominant erosion processes appeared to be freeze/thaw and dry ravel; gullying and/or mass wasting of the prism was negligible. Perhaps most importantly, topographic conditions at the crossing flattened as the road approached the stream crossing, thus promoting energy dissipation and infiltration of ditch flows, and sediment deposition in the ditch before drainage reached the stream. Since there was not evidence of sediment delivery to the stream via the ditch, the BMPs implemented at this road segment are rated effective. A follow-up inspection in June 1995 confirmed a lack of evidence of sediment delivery.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Sherry R-07

Treatment Survey ID#: CS-04 Water Type: 3
Control Survey ID#: CS-03 Water Type: 3

BMP(s) Evaluated: Road Construction (Stream Crossings, Construction Techniques, Drainage Design)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	64	8/26/93	65	8/26/93
Post-Treatment Survey #1:	51	6/28/94	61	6/28/94
Change from Pre-Treatment Score:	-13		-4	
Net Change (Control-Treatment):	-9			
Post-Treatment Survey #2:	49	6/19/95	56	6/19/95
Change from Pre-Treatment Score:	-15		-9	
Net Change (Control-Treatment):	-6			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
The net decrease in the treatment reach score is attributable primarily to increases in fresh sediment deposits, deposition of fines in pools, increased bank erosion and flow deflection into banks, and increased bed mobility. In addition to the scores, comments on the survey forms documented the following noticeable differences between the treatment and control reaches: more rooted aquatic vegetation in the control, brighter substrate (less algal staining) in the treatment, and a greater amount of fresh deposits in the treatment. The overall morphology and substrate character of the reaches (average channel gradients are 4.5 and 5.8%) are indicative of a moderate potential to store fine sediment deposits within the channel as well as on the floodplain and side channel areas. Stream banks and wet floodplain areas are highly susceptible to physical disturbance. The introduction of fresh sediment to the treatment reach is attributable to the crossing of the stream by a new road, which is immediately upstream of the treatment reach. Delivery is via a ditchline draining cutslopes and the insloped portion of the road surface and from the fill immediately adjacent to the stream. The road also parallels the treatment reach. Although adverse in-stream effects from the road construction were apparent in the treatment reach, the net decrease did not exceed the 10 point threshold, resulting in an "effective" rating.

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Sherry R-07

Treatment Survey ID#: CS-06 Water Type: 3
Control Survey ID#: CS-01 Water Type: 4

BMP(s) Evaluated: Road Construction (Stream Crossings, Construction Techniques, Drainage Design)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	61	8/26/93	62	6/3/93
Post-Treatment Survey #1:	52	6/28/94	59	6/28/94
Change from Pre-Treatment Score:	-9		-3	
Net Change (Control-Treatment):	-6			
Post-Treatment Survey #2:	none			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
The net decrease in the treatment reach score is attributable primarily to increases in fresh sediment deposits, deposition of fines in pools, and destabilization of sediment storage elements. The overall morphology and substrate character of the reaches (average channel gradients are 5-6%) are indicative of a moderate potential to store fine sediment deposits within the channel. The introduction of fresh sediment to the treatment reach is attributed to construction phase erosion during culvert installation, as well as chronic erosion in the immediate vicinity of the culvert fill; the new culvert is located immediately upstream of the treatment reach. Delivery of sediment via a long ditchline constructed to drain a segment of the road was not indicated; road drainage appeared to infiltrate or drain outsloped before reaching this stream. Although sediment effects from the road construction were apparent in the treatment reach, the net decrease in channel condition score did not exceed the 10 point threshold, resulting in an "effective" rating.

Stream Bank Erosion Survey Summary

Stream Bank Erosion Survey				Stream Bank Erosion Survey			
Site: Sherry Creek	Treatment (Road Construction - Stream Crossing)			Site: Sherry Creek	Control		
Survey Dates: 8/93 & 6/94	Water Type: 3			Survey Dates: 8/93 & 6/94	Water Type: 4		
Survey #: SE-03	Total reach length center line: 61.0M			Survey #: SE-01	Total reach length center line: 56.0M		
	Length of left bank: 67.3M				Length of left bank: 62.0M		
	Length of right bank: 68.9M				Length of right bank: 59.0M		
	Total bank length: 136.2M				Total bank length: 121.0M		
		Year				Year	
		1993	1994			1993	1994
Total # eroding banks		2	4	Total # eroding banks		4	5
Total # Sampled		2	4	Total # Sampled		4	5
Total length of eroding banks		1.5M	4.4M	Total length of eroding banks		2.3M	2.7M
Total area of eroding banks		0.5 sq. m.	1.8 sq. m.	Total area of eroding banks		3.1 sq. m.	1.0 sq. m.
% of bank length eroding:		1.1%	3.2%	% of bank length eroding		1.9%	2.2%
Cause of Bank Erosion:		Length of Eroding Bank:		Cause of Bank Erosion:		Length of Eroding Bank:	
Yarding Scar/Road Construction		1.0M	0	Wildlife		1.0M	1.1M
Wildlife/Livestock		0.5M	4.4M	Flowing Water		1.3M	0
				Unknown		0	1.6M

Forest practices evaluated were new road construction with a culverted stream crossing of the type 3 stream (was classified as type 4 on the FPA, but salmonid use was observed during field surveys in two different study reaches). The road crossing defined the upstream end of the SE-03 treatment reach. The yarding/road construction scar documented during the 1993 survey was not identified as continuing to erode in the 1994 survey. The area below (downstream) of the road crossing was at the outer edge of the Sherry Creek RMZ and was not impacted by the harvesting activities. The eroding banks observed in 1994 were attributed to disturbance by wildlife and/or livestock activity, most likely cattle which had been observed in this area.

BMP Effectiveness Rating: EFFECTIVE

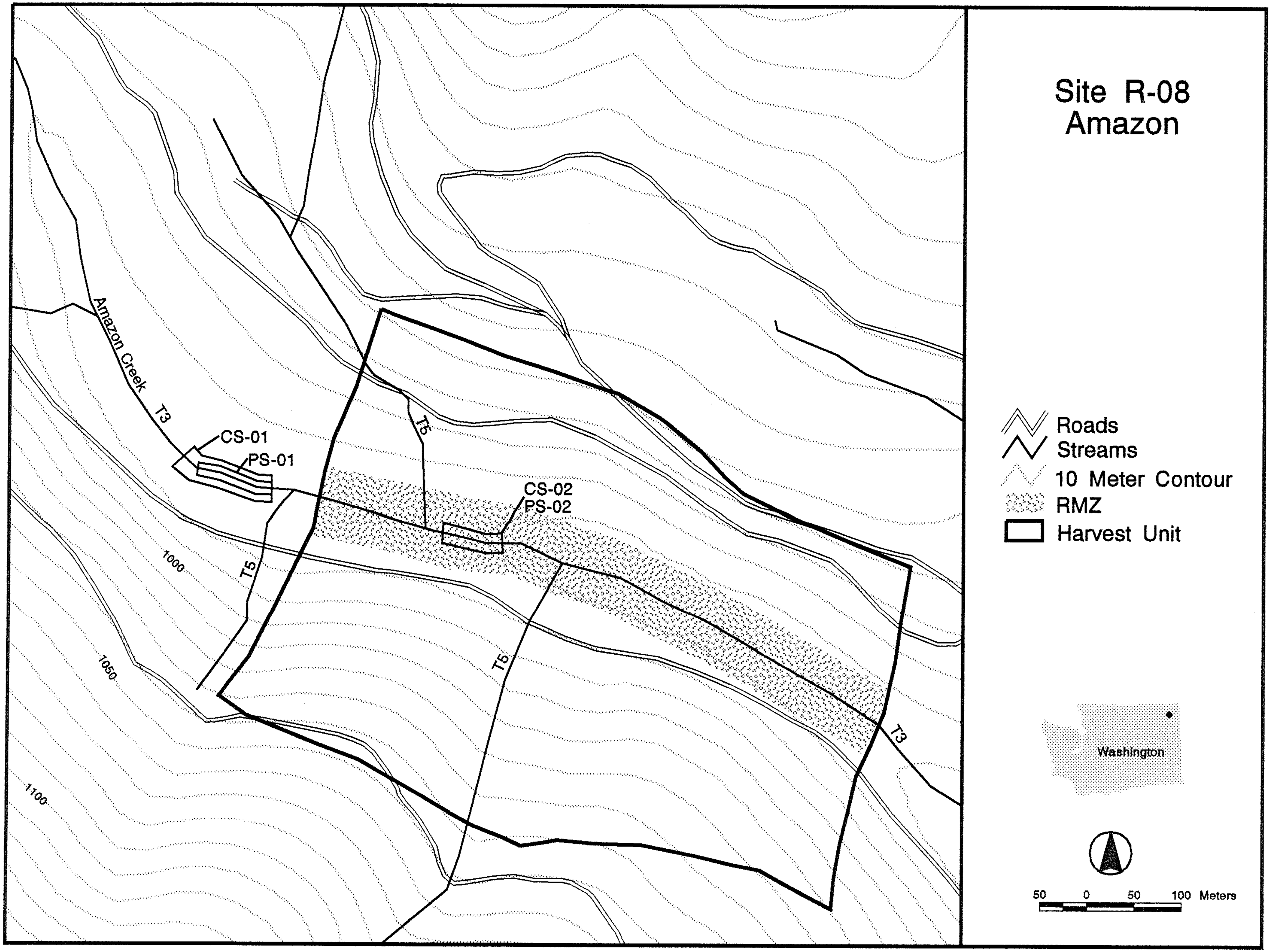
Site R-08: Amazon

The Amazon site is located in eastern Stevens County in the Northern Rockies physiographic region. Timber harvesting practices were evaluated at this site. Amazon is part of the CMER Wildlife-RMZ research project, and our BMP effectiveness surveys were co-located with the wildlife-RMZ study transects. The surface geology of the site is mapped as undifferentiated glacial drift deposits, which overlay granitic bedrock. 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, 0-25% slopes. The Nevine soils are rated as unstable for disturbed slope stability, with a severe cutbank/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 cutbank/fill/sidecast hazard and low to medium erosion potential. The harvest BMP slope hazard category for the site is low, based on stream valley side slope gradients of 5% to 10% measured in the vicinity of the study reach in the upstream portion of the RMZ.

The study stream at this site is Amazon Creek, a 3rd order, Type 3 stream that is a tributary of the Little Pend Orielle River. This stream has a pool-riffle channel morphology, with an average active channel width of 2 meters and a gradient of 1% in the upper reach of the RMZ.

Forest practices conducted at the Amazon site include a 43 hectare partial cut harvest with 40% volume removal, using ground-based yarding methods. A RMZ was established along Amazon Creek. The width of the RMZ was about 39 meters in the vicinity of in-stream surveys. Timber harvest was completed in October of 1993.

BMPs evaluated at this site were the RMZ along Amazon Creek and adjacent ground-based harvest practices. Channel condition and photo point surveys were conducted in July 1993 and June 1994 on one RMZ treatment reach on Amazon Creek, and one control reach located on the same stream upstream of the harvest unit boundary. Riparian amphibian surveys were conducted along Amazon Creek and the RMZ by investigators from Eastern Washington University and Washington State University, as part of the CMER Wildlife-RMZ research project.


Site R-08
Amazon
Roads
Streams
10 Meter Contour
RMZ
Harvest Unit
Washington
50 0 50 100 Meters
Amazon Creek
T3
T5
CS-01
PS-01
CS-02
PS-02
1000
1050
1100

Harvest BMP Effectiveness Summary

Study Site: R-08: Amazon - Partial cut harvest with RMZ

	Survey Employed	BMP Effectiveness Ratings: Harvest w/ RMZ & Streambank Integrity BMPs (WAC 222-30-020(2-4) & -030 & -040 & 050) — Ground-based Yarding WAC 222-30-070	Harvest w/ RMZ & Streambank Integrity BMPs — Cable Yarding WAC 222-30-060	Harvest with no buffers (Type 4 and/or 5 Waters) — Ground-based Yarding WAC 222-30-070	Harvest with no buffers (Type 4 and/or 5 Waters) — Cable Yarding WAC 222-30-060	Harvest with RLTAs (Type 4 and/or 5 Waters) (WAC 222-30-020(5)) — Ground-based Yarding WAC 222-30-070	Harvest with RLTAs (Type 4 and/or 5 Waters) — Cable Yarding WAC 222-30-060
ASPECT 1: Effectiveness in terms of chronic erosion with delivery to surface waters.	No separate erosion/delivery surveys were conducted.						
Case Narrative:	While no separate erosion/delivery surveys were conducted to evaluate harvest practices at the Amazon site, it was noted during in-stream surveys that there was no evidence of direct delivery of sediment from harvest practices in the vicinity of the RMZ study reach. It was observed that there was limited harvest of trees from within the RMZ, including some logging activity within 10 meters of the stream.						
ASPECT 2: Effectiveness in terms of local stream impacts and response (sedimentation, physical integrity, and/or biological integrity).	Channel Condition: CS-02/CS-01	Effective					
	Photo Point: PS-02/PS-01	Effective					
Case Narrative:	Stream channel conditions in the RMZ treatment reach were not affected by timber harvest activities. Conditions within both the RMZ study reach and the upstream control reach were virtually unchanged, comparing conditions from before to after the harvest. Minor stream bank disturbance by cattle was observed in the treatment reach. Photo point surveys did not show any new windthrown trees crossing the channel over the 11 month monitoring period in either the 68 meter RMZ reach or the 83 meter control reach. One recent windthrow (not crossing the stream) was observed during the post-harvest channel condition survey in the RMZ reach.						
	OVERALL SITE BMP EFFECTIVENESS RATING:	EFFECTIVE					

CHANNEL CONDITION SURVEY RATING SUMMARY

Study Site: Amazon R-08

Treatment Survey ID#: CS-02 Water Type: 3
Control Survey ID#: CS-01 Water Type: 3

BMP(s) Evaluated: RMZ (Partial Cut Harvest with Ground-based Yarding)

CS Scoring Summary

	Treatment Score	Survey Date	Control Score	Survey Date
Pre-Treatment Surveys:	49	7/30/93	51	6/4/93
Post-Treatment Survey #1:	47	6/30/94	50	6/30/94
Change from Pre-Treatment Score:	-2		-1	
Net Change (Control-Treatment):	-1			

BMP EFFECTIVENESS CALL: EFFECTIVE

Case Narrative:
There were virtually no changes in channel condition observed in either treatment or control reaches, which are both on the same stream. The survey reaches are both low gradient (1%), with a pool-riffle morphology heavily influenced by beaver activity, and have high potentials for storing fine sediment. A large beaver pond/wetland just upstream of the study reaches encourages stable channel conditions by attenuating peak flow events. Channel stability was evident from the extensive periphyton growth, with even the finer sediment deposits often being vegetated. It was noted that there was logging activity within 10 meters of the stream, including limited harvest of trees within the RMZ, but no physical disturbance of stream bed or banks was observed. Logging activity did not occur within the floodplain, which contained numerous side channels and areas of standing water. At least one recent windthrow was observed along the treatment reach during the post-treatment survey. Minor bank disturbance by large animals (e.g. cattle) was observed in the treatment reach. Numerous trout were observed in both treatment and control reaches.

In-Stream Photo-Point Survey Comparison Summary

Site: Amazon

Survey Dates: 7/30/93 & 6/30/94

Study Reach Descriptions: 68 meter treatment reach in RMZ, and 83 meter control reach upstream of the harvest unit on the same stream.

Indicators of in-channel changes	Control PS-01 Yes	Control PS-01 No	Treatment PS-_02 Yes	Treatment PS-_02 No
1. Is there evidence of increased stream bank erosion and /or physical disturbance of banks?		X		X
2. Is there evidence of destabilization of sediment storage elements or bedforms (e.g. embedded LWD, boulder clusters)?		X		X
3. Is there evidence of increased stream bed mobility (e.g. change in brightness, fresh sediment deposits)?	X			X
4. Is there evidence of increased deposition or storage of fine or coarse sediment?		X		X
5. Are there changes in woody debris? (indicate numbers of windthrown trees documented over the survey period)				
Increase in large WD?		X		X
Increase in small WD?	X			X
Decrease in WD?		X		X
6. Is there evidence of changes in aquatic plants due to scouring or other disturbances?		X		X

Summary:

Very little if any changes were apparent in the year-to-year comparison of photos for either study reach. Small area of fresh sediment noted in control reach. No new windthrow was observed crossing the channel in either study reach.

BMP Effectiveness Rating: EFFECTIVE