departures from the rule (unacceptable implementation). The effectiveness of each of these implementation categories in preventing erosion, sediment transport and sediment transport to channel is shown in Table 7, below.

Road-related Features Implementation Rating	Effectiveness Problems		
	Erosion	Sediment Transport	Transport to Channel
Exceeds Rule/THP requirement n = 57	2%	0%	0%
Acceptable n = 893	5%	1%	1%
Marginally Acceptable n = 142	23%	9%	1%
Departures n = 55	53%	35%	11%

Table 7. FPR effectiveness: road-related feature implementation ratings vs. percent of features with effectiveness problems.

The results shown in Table 7 demonstrate that the FPRs were very effective in preventing erosion and sediment transport related to roads. When implementation exceeded the rule requirements, erosion was found only 2% of the time, and no evidence of sediment transport or sediment transport to a channel was observed. With acceptable implementation of the FPRs, erosion was found 5% of the time, and evidence of sediment transport or sediment transport to a channel was observed only 1% of the time. However, when implementation of the FPRs was marginally acceptable, erosion was found 23% of the time, sediment transport was seen at 9% of the evaluated features, but evidence of sediment transport to a channel was still observed only 1 percent of the time. When implementation was rated as departing from the FPRs, erosion was found at more than half of the road-related features, sediment transport was seen 35% of the time, and evidence of sediment transport to channels was found at 11% of the evaluated sites, which indicates a noticeable reduction in water quality protection.

In summary for roads, when there is a departure from the rule, the chance of erosion is about 1 in 2, the chance sediment transport is about 1 in 3, and the chance of sediment transport to a channel 1 in 10. But where the FPR implementation is acceptable or better, the chance of erosion is about 1 in 20, and the chance of sediment transport or sediment transport to a channel is equal to or less than 1 in 100.

Sediment transport to a channel can lead to water quality impacts. Evidence of transport to channels was seen on 9 road-related features out 1,147 rated for effectiveness, which is about 0.8 percent. Implementation ratings for these nine road-related features included three rated as acceptable, one rated as marginally acceptable and five rated as departures from the rule. Two of three features rated as acceptable and the one feature rated as marginally acceptable were located at watercourse crossings in the sampled road segments. The remaining feature rated as acceptable involved a road drainage site impacted by a high-intensity storm. Of the five features rated as departures, two involved discharges onto erodible material or failure to discharge into cover. The other three departures were related to inadequate numbers of drainage facilities/structures or inadequate spacing.

III. Discussion

The FPRs related to roads were found to be properly implemented 96% of the time and, when properly implemented, effectively prevented erosion from most road features. Where erosion did occur, proper rule implementation prevented nearly all road-related sediment transport and discharge into channels. The infrequent departures from the road rules were associated with most of the road-related erosion, sediment transport, and sediment deposition in channels. Departures with potential to impact water quality were generally related to inadequate drainage and failure to discharge onto non-erodible sites. From a management and regulatory standpoint, it is useful to note that departures with potential to impact water quality occur on only 5% to 6% of road segments, or about one mile out of every twenty miles of THP roads. As a result, finding and fixing drainage problems on the worst 5% of all road segments would produce the greatest reduction in road-related water quality impacts for the least amount of money.

The MCR road results compare reasonably well with earlier monitoring work conducted in California on non-federal timberlands. In the HMP, Cafferata and Munn (2002) reported that 93.2% of the road rules evaluated for implementation were rated as acceptable. Where there was sediment transport to watercourse channels documented, erosion features were usually caused by a drainage feature deficiency, and the FPRs rated at these problem sites were nearly always found to be out of compliance. Most of the identified road problems were related to inadequate size, number, and location of drainage structures; inadequate waterbreak spacing; and lack of cover at waterbreak discharge points. Approximately 15% of the inventoried erosion features delivered sediment to watercourse channels, compared to 11% percent sediment delivery at rule departure sites in the MCR. Only 5.5% of the drainage structures evaluated along the road transects in the HMP were found to have problems.

The FPRs do not apply to federal lands, but the USFS has an analogous set of road-related BMPs. The USFS (2004) reported that from 1992 through 2002 on California National Forests, BMPs for road surface, drainage, and slope protection were implemented at 85% of the 284 sites evaluated. At the 40 sites where these BMPs were not implemented, consistency of drainage structure repair with road management objectives was the criterion for which both minor and major departures were most common. BMPs were effective 90% of the time that they were implemented. At the sites where effectiveness objectives were not met, minor departures were most frequently associated with rilling on road surfaces and fillslopes. Sediment discharges to stream management zones (SMZs) or stream channels were the most common type of major departures. Effects were classified as elevated at less than 5% of the sites. Inadequate BMP implementation caused the elevated effects at all but one of these sites.

In their current form, the road-related FPRs are complicated and not organized well in the Forest Practice Rule Book. A Road Rules Committee of the Board of Forestry and Fire Protection is currently working on ways to revise and streamline these rules. This has the potential to further improve the effectiveness of road-related FPRs by making them easier to implement and enforce and also has the potential to make the rules easier to monitor in future MCR efforts.

The form used for data collection by this MCR monitoring study needs to be revised for future MCR monitoring. The current form was modeled after the form used in the HMP, where most of the observations were made by one team of observers (a single contractor) working closely together in the field. In contrast, the MCR observations were made by multiple observers (CDF Forest Practice Inspectors), and the complexity of the form caused inconsistencies in data collection from multiple observers working at various, disparate locations. Therefore, the data collection form should be simplified to focus on factors related to drainage spacing and adequacy, discharge into groundcover, and percent road grade between drainage structures that this study and others have found to be most closely associated with erosion and sediment transport. A revised road form for future MCR monitoring is currently being developed and will be available for field testing later in 2006.

MCR Monitoring:
Watercourse Crossings

I. Methods

Monitoring Timelines and Site Selection

The first two permanent or abandoned crossings on Class I, II, or III watercourses encountered along the randomly located 1000-foot road transect (as described in the Road Section of this report) were selected for MCR monitoring (Figure 25). Inspectors were instructed to sample the first crossing that was available and to not be concerned whether these features were distributed throughout the THP area or whether similar types of crossings were being evaluated.

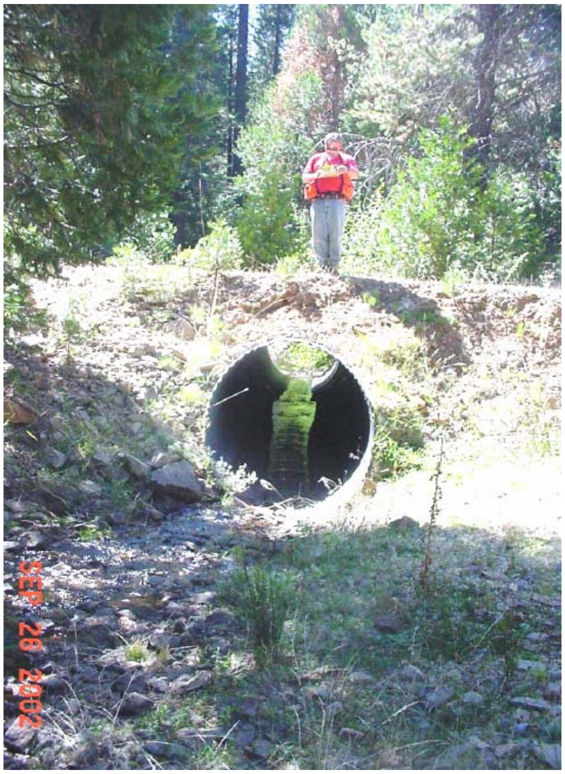

Figure 25. Clay Brandow, CDF, rating implementation and effectiveness for a Modified Completion Report watercourse crossing in the central Sierra Nevada Mountains.

If no crossings were noted within the 1000-foot road transect, then inspectors selected the closest watercourse crossings shown on the THP map relative to the randomly chosen road transect. If there were no watercourse crossings associated with roads, then the nearest skid trail crossings were evaluated. If there were no watercourse crossings within the THP, this information was recorded at the beginning of the

Watercourse Crossing form package.

The area to be included in the watercourse crossing evaluation was determined by inspecting the road prism in both directions from the crossing and identifying the points where drainage from the road surface, cuts, and fills was no longer transported to the crossing. The evaluation also included the drainage structures on the road immediately upslope from the crossing that should route water away from the crossing (e.g., “cut-off” waterbar). The road length for evaluation was located between these points.

The *MCR Methods and Procedures* guidelines specified that each of the selected crossings was to be rated on two separate occasions:

1) During field inspection of the THP Work Completion Report, CDF’s Forest Practice Inspector recorded site information on the MCR field form and rated implementation of applicable Forest Practice Rules for the selected watercourse crossing; and

2) The Inspector was asked to use the same form to rate rule effectiveness after at least one over-wintering period during the Erosion Control Maintenance Period.[3]

Watercourse Crossing Site Information

The following site information was included on the Watercourse Crossing Implementation Form:

- watercourse class (i.e., I, II, III, or IV – see glossary for definitions),
- road type (i.e., permanent, seasonal, temporary, or abandoned),
- crossing type (i.e., culvert, ford, bridge, etc.),
- crossing status (i.e., existing or abandoned),
- culvert diameter (if appropriate), and
- installation date (i.e., installed prior to the THP or newly installed as part of THP).

The crossing site information and implementation field form is displayed in Appendix A.

Watercourse Crossing Forest Practice Rule Implementation Rating

Following completion of the site information portion of the form, the Inspector rated implementation of 27 FPR requirements for roads and crossings found in 14 CCR § 923 [943, 963] and three Rule requirements for skid trails and crossings (referred to as tractor roads in the FPRs) found in 14 CCR § 914 [934, 954] using one of the following five implementation codes:

[3] This did not occur on a majority of the evaluated sites. Data on a second time period effectiveness evaluation is provided in the watercourse crossing results section.

D - Departure
MA - Marginally Acceptable
A - Acceptable
ER - Exceeds Rule/THP Requirements
N/A - Not Applicable

Watercourse Crossing Effectiveness Rating

The Watercourse Crossing Effectiveness Form was patterned after the crossing form (E09) developed by the USFS as part of their Best Management Practices (BMP) Evaluation Program (USFS 1992; USFS 2004), as well as a simplified version of the field forms developed for the BOF's Hillslope Monitoring Program (Cafferata and Munn 2002). Features rated for effectiveness were included within the following major categories: fill slopes, road surface drainage to the crossing, culvert design/ configuration, non-culverted crossings, and removed/abandoned crossings. In most cases, the effectiveness rating was selected from a description that generally can be summarized by one of the following four categories: not applicable (N/A), not a problem ("none" or "slight"), a minor problem, or a major problem. The Watercourse Crossing Effectiveness Form is displayed in Appendix A, and the following is a description of the rating criteria used for the 27 different crossing features.

FILL SLOPES

Gullies: Gullies were defined as being greater than 6 inches deep. The major problem category was checked if the gullies were significant and appeared to be enlarging.

Cracks: Cracks on fill slopes were assessed to determine whether they appeared to be stabilized or were widening, threatening the integrity of the fill.

Slope Failures: Slope failures were defined as movement of soil in blocks, rather than by rills, gullies or sheet erosion. The Inspector estimated whether fill slope failure(s) at the crossing site totaled between 0 and 1 cubic yard (minor problem), or greater than one cubic yard (major problem).

ROAD SURFACE DRAINING TO THE CROSSING

Gullies: Gullies on the road surface draining towards the crossing were rated as a major problem if they appeared to be enlarging or depositing sediment into a watercourse channel.

Cutoff Drainage Structure: Cutoff drainage structures were evaluated to determine if they were preventing water from reaching the crossing location. The major problem category was selected when water was reaching the crossing.

Inside Ditch Condition: When an inside ditch was present, its condition was evaluated to determine how functional it was in routing water to the culvert inlet. The major problem category was picked if the ditch was blocked with sediment or debris.

Ponding: The road surface was inspected for evidence of surface water ponding. A major problem was defined as ponding that threatened the integrity of the fill material.

Rutting (from vehicles): When vehicle ruts were present, the major problem category was selected if they impaired road drainage.

CULVERT DESIGN/CONFIGURATION

Crossing Failure: The Inspector determined whether the crossing had failed (yes/no) and recorded an estimate of cubic yards of fill lost at failure sites.[4]

Scour at Inlet and Outlet: The total amount of scour that had occurred and was likely to occur in the next two years at both the inlet and outlet of the culvert was estimated. The presence of significant scour, which may have undercut the fill material, was used to identify major problems.

Diversion Potential: Diversion of streamflow at crossings can transport large amounts of sediment to stream channels. The amount and direction of road surface slope at the crossing was used to determine whether the stream would be diverted down the roadway if flow exceeded the culvert capacity or the culvert was plugged with wood or sediment.

Plugging: The inlet and outlet of the culvert were inspected to determine the presence of debris (i.e., small wood, soil or rock) and, if debris was present, the degree of blockage. The major problem category was selected if more than 30% of the pipe opening was obstructed.

Alignment: The channel configuration was evaluated at the culvert inlet to determine if the pipe was properly aligned with the channel. A major problem was indicated by the presence of a considerable angle for the channel approach.

Degree of Corrosion: For steel pipes, the competency of the metal was evaluated. The major problem category was assigned if the pipe could be easily punctured.

Crushed Inlet/Outlet: The Inspector determined if the pipe inlet or outlet had been deformed. Less than 30% blockage by crushing was defined as a minor problem, and greater than 30% was a major problem.

Pipe Length: Pipe length was evaluated to determine if it was appropriate for the fill placed at the crossing, or whether insufficient culvert length was causing significant erosion problems.

Gradient: Improper culvert gradient was indicated when the pipe inlet was set too low

[4] This data was frequently not recorded.

or too high in the fill causing debris accumulation, unless this was intended for fish passage and the remaining culvert area provided sufficient flow capacity.

Piping: The crossing fill was inspected to determine if streamflow was passing beneath or around the culvert, without being routed through the pipe.

NON-CULVERT CROSSINGS (e.g., Rocked Ford)

Armoring: The amount and size of applied rock and cobbles at the crossing were observed to determine if minor or major downcutting was occurring at the crossing site.

Scour at Outlet: The total amount of scour that had occurred and was likely to occur in the next two years was observed at the crossing outlet. The presence of noticeable scour was used to indicate a major problem.

Diversion Potential: The watercourse crossing and approaches were examined to determine if they would prevent diversion of stream overflow down the road if the drainage structure became blocked. A major problem was indicated if water had or would flow down the road instead of being directed off the road surface.

REMOVED OR ABANDONED CROSSINGS

Bank Stabilization: Bank cuts were evaluated to determine if cover prevented transport of exposed surface soil to a watercourse. The major problem category was selected when less than 50% of the banks had effective cover.

Gullies: Gullies were defined as being greater than 6 inches deep. The major problem category was used when large gullies were present and appeared to be enlarging.

Slope Failure: The volume of fill slope failure(s) at the crossing was estimated and ratings were assigned based on totals of less than 1 cubic yard (slight), greater than 1 cubic yard without channel entry (minor), or greater than 1 cubic yard and deposition into a stream channel (major).

Channel Configuration: The restored channel configuration was examined at abandoned and removed crossings to determine if it was wider than the natural channel and as close as feasible to the natural watercourse grade and orientation. Small differences from natural channel width, grade, or orientation were rated as a minor problem, while a major problem was assigned when there were significant differences from natural channel width, grade, or orientation.

Excavated Material: The channel was observed to determine if banks had been sloped back and stabilized to prevent slumping and minimize sediment input into the channel. A minor problem was defined as having less than 1 cubic yard of excavated material transported to the channel, and a major problem was identified when greater than 1 cubic yard of material had entered the channel.

Maintenance Free Drainage: The abandonment procedure was evaluated to determine if it was providing permanent, maintenance free drainage, or if minor/major problems were noted.

II. Watercourse Crossing Results

General Results

A total of 357 watercourse crossings were rated for implementation from 2001 through 2004, and 289 of these crossings were rated for effectiveness (Table 8.) Of these crossings, 63% were located on the Coast (CDF Region 1), 25% were in Inland North (CDF Region 2), and 12% were in Inland South (CDF Region 4). The intention was to rate all 357 watercourse crossings for effectiveness; however, 68 had not been rated for effectiveness by July 2004 when MCR data collection was suspended due to budget uncertainties.

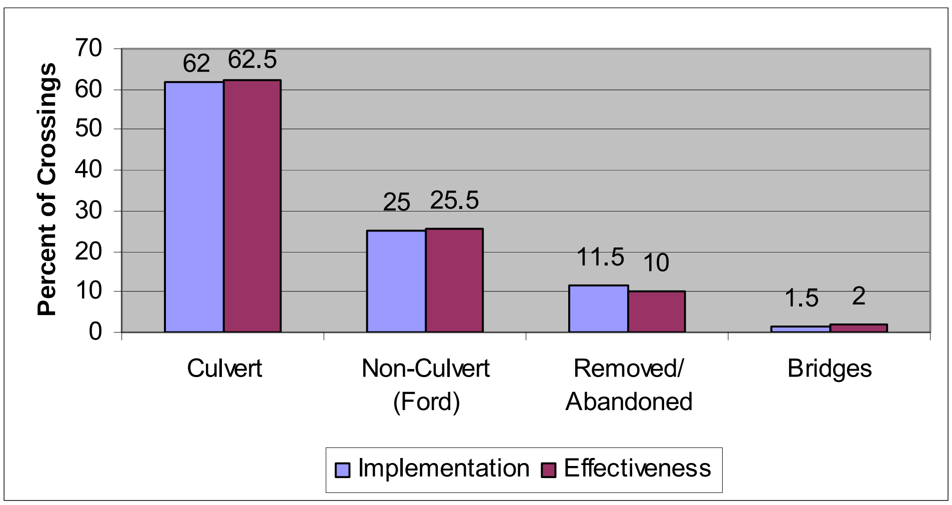

Figure 26. Distribution of watercourse crossing types for both the implementation and effectiveness evaluations.

Watercourse Crossing Type	Implementation	Effectiveness
Culvert	221	181
Non-culvert (ford)	89	74
Removed/Abandoned	41	29
Bridge	6	5
Total	**357**	**289**

Table 8. Distribution of watercourse crossing types rated for implementation and effectiveness from 2001 through 2004.

The proportions of crossing types were very similar in both implementation and effectiveness data sets (Figure 26, Table 8). For the implementation ratings, approximately 62% of the crossings were culverts, 25% were non-culverted crossings (mainly fords), 11.5% were removed or abandoned crossings, and 1.5% were bridges. Of the crossings rated for implementation, 59% were located in Class III watercourses, 34% were in Class II watercourses, 4% were in Class I's, and 1% were in Class IV watercourses (with missing data on 2%) (Figure 27). Nearly all the non-culverted crossings were in Class III watercourses, while the proportions of crossings with culverts were nearly the same in Class II and III watercourses. Bridges were almost entirely associated with Class I watercourses, and removed/abandoned crossings were mostly found in Class II and III watercourses (Table 9).

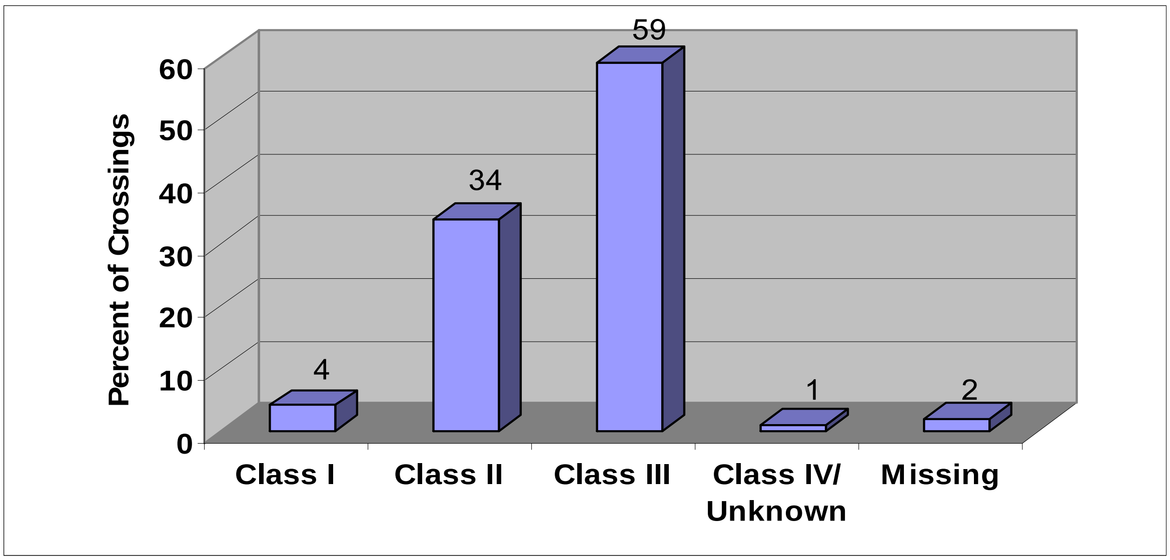

Figure 27. Percentages of the sampled watercourse classes.

Watercourse Class	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
I	5	6	0	4	15
II	1	94	8	17	120
III	0	112	79	20	211
IV	0	4	0	0	4
Missing Data	0	5	2	0	7
Total	**6**	**221**	**89**	**41**	**357**

Table 9. Watercourse classes summarized by watercourse crossing types.

Almost three-quarters (74%) of the crossings with culverts were found on seasonal roads, and about a quarter (24%) were on permanent roads (Table 10). Similarly, 83% of the non-culverted crossings were associated with seasonal roads. Removed or abandoned crossings were approximately equally distributed between seasonal roads and skid trails, and were found to a lesser degree on temporary roads. Bridges were found on permanent and seasonal roads.

Road Type	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
Permanent	2	54	3	0	59
Seasonal	4	163	74	17	258
Temporary	0	2	3	8	13
Skid Road	0	2	7	14	23
Combined Categories	0	0	2	0	2
Missing Data	0	0	0	2	2
Total	**6**	**221**	**89**	**41**	**357**

Table 10. Distribution of watercourse crossing types summarized by road type.

For crossings with culverts, 67% had pre-existing culverts and 33% of the crossings had new pipes installed as part of the THP. Roughly half the non-culverted and removed/abandoned crossings (46% and 51% respectively) were new, and one-third (33%) of the evaluated bridges were classified as being installed as part of the plan (Table 11).

Crossing Status	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
Existing	4	149	48	16	217
New	2	72	41	21	136
Missing Data	0	0	0	4	4
Total	**6**	**221**	**89**	**41**	**357**

Table 11. Crossing types installed as part of the plan or prior to the plan date.

The distribution of pipe sizes for crossings with culverts is displayed in Figure 28. This diagram shows that approximately 41% of the pipes were 18 inches in diameter, 21% were 24 inches, 12% were 36 inches, and 7% were 48 inches or larger. Figure 29 illustrates that the majority of the Class III watercourses had 18 inch diameter pipes, while Class II watercourses had a more equal distribution of 18, 24, and 36 inch pipes. Class I watercourses had 48 inch and larger CMPs installed, while Class IV's had 24 inch and smaller diameter pipes.

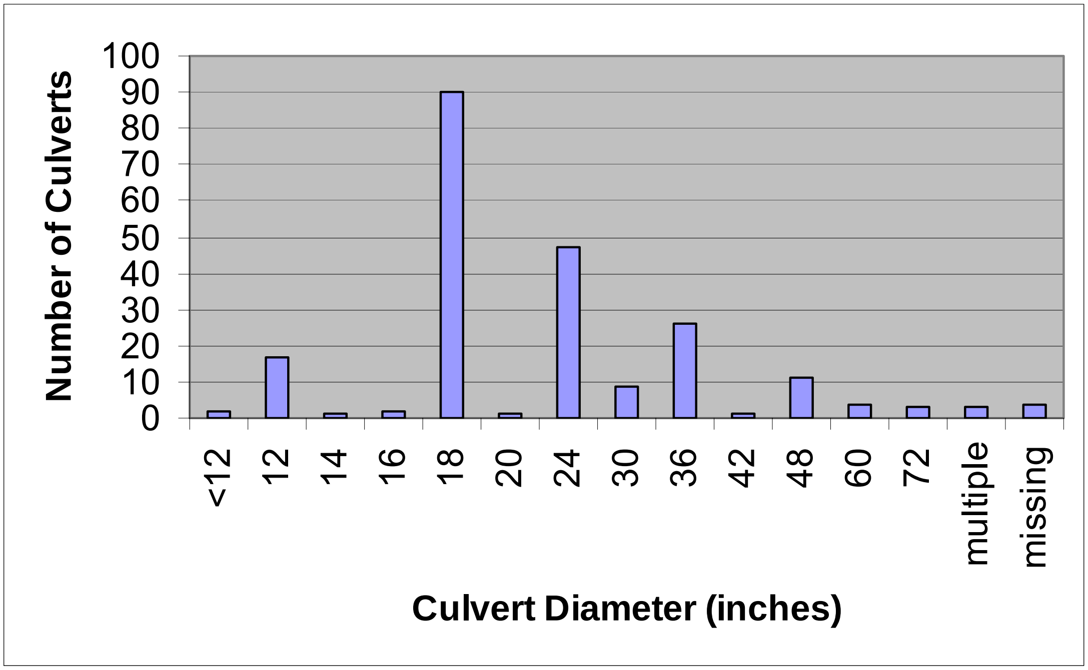

Figure 28. Culvert size distribution for watercourse crossings with pipes.

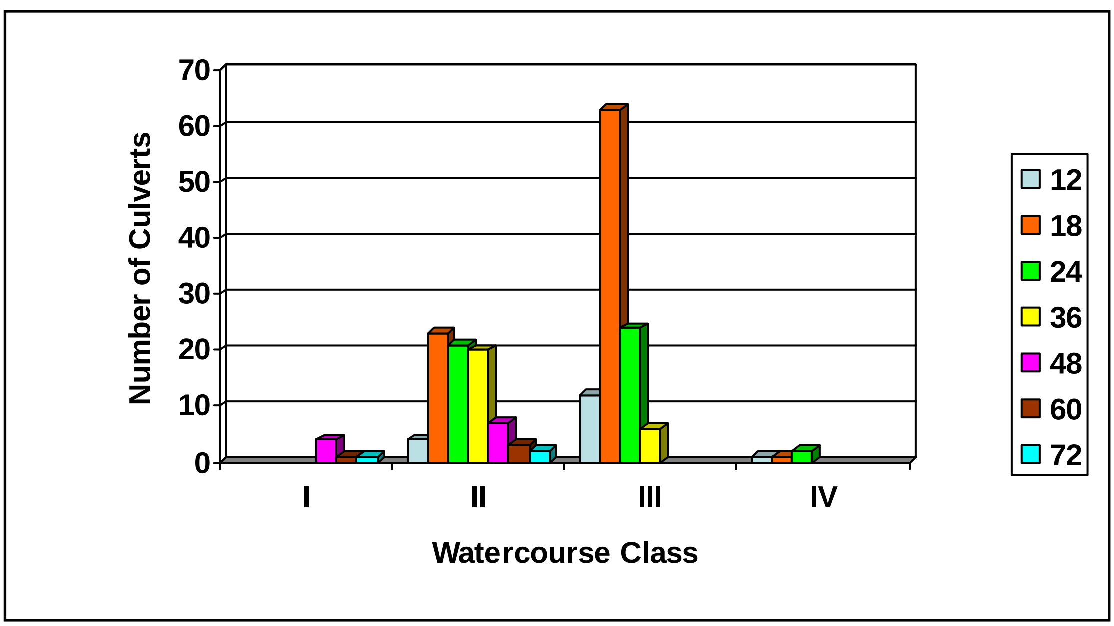

Figure 29. Distribution of culvert diameter categories (inches) by watercourse classes.

Approximately 80% of the watercourse crossings rated for implementation were also rated for effectiveness. These effectiveness ratings occurred at three different times, depending on the crossing being monitored (Table 12). About three-quarters (76%) of the effectiveness ratings were done on or about the same day as implementation ratings. Effectiveness ratings were made during a second field visit 13% of time, which usually took place one to two years later. In addition, 11% of the crossings had effectiveness evaluations conducted both when the initial implementation rating was done and a second time one to two years later. Therefore, almost 25% of the time, watercourse crossings were rated for effectiveness one to two years following an initial implementation rating.

Effectiveness Rating	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total	Percent
Only at time of Implementation	4	136	60	19	219	**76%**
Only at second visit	0	26	6	6	38	**13%**
Second rating at second visit	1	19	8	4	32	**11%**
Total	**5**	**181**	**74**	**29**	**89**	**100%**

Table 12. Distribution of effectiveness rating time periods for different watercourse crossing types.

Watercourse Crossing Implementation Results

Implementation of FPR requirements was rated using the following compliance categories: Departure (D), Marginally Acceptable (MA), Acceptable (A), Exceeds Rule/THP Requirement (ER), and Not Applicable (NA). These criteria were applied to 30 individual rule requirements, including 27 road rules found in 14 CCR § 923 [943, 963] and three rules related to skid trails found in 14 CCR § 914 [934, 954]. Implementation data is presented below in Table 13 for all the crossing types combined; and separately for existing culverts, new culverts, non-culverted crossings and removed/abandoned crossings (combined), and bridges.[5]

[5] Note that the numbers of crossings included for each crossing type for implementation are slightly different than those presented in the previous section due to minor adjustments made when compiling data with hand counts.

Rule Number	Rule Description	Total Obs. (w/out NA)	Departure (%)	Departure plus Marginally Acceptable (%)
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to adequately reform channel	91	7.4	21.3
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	246	6.9	18.7
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	65	6.2	23.1
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	35	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	35	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills appropriate	35	5.7	8.6
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	36	5.6	11.1
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	130	5.4	19.2
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	301	5.0	18.3
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	127	4.7	11.0

Table 13. Forest Practice Rule requirements for all watercourse crossing types with at least four percent departures based on at least 30 observations where implementation could be rated (i.e., excludes N/A observations).

The number of observations available for analysis is not the same for each rule requirement because many requirements were not applicable at all crossing sites. There are also different numbers of observations for each crossing type, which leads to large differences in numbers of observations among rule and crossing type combinations. As a result, the following discussion of combined crossing types has been limited to those rules with as least 30 observations to include results from both active and abandoned/removed crossings, and discussion of results for individual crossings types is limited to rules that are applied on at least 20% of the applicable sites.

All Crossing Types

Twenty-five specific FPRs related to watercourse crossings were observed and rated for implementation at 30 or more crossings. Ten of these 25 FPRs had departure rates of 4% or higher, as shown in Table 13, and most of these had departure rates between 5% and 7%.[6] Five of these ten FPR requirements relate to removed or abandoned crossings. When crossings with marginally acceptable ratings are included, the proportion of sites with implementation problems ranges from about 9% to 23%.

The FPR requirement with the highest overall departure rate was 14 CCR § 923 [943, 963], which requires removed crossings to have fills excavated to form a channel that is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel.[7] The FPRs requiring crossings to be constructed or maintained to prevent diversion potential, 14 CCR § 923.4 [943.4, 963.4] (n) and § 923.3 [943.4, 963.4] (f), had departure rates of 6.9 and 5.0%, respectively. A complete list of the implementation ratings for all the watercourse crossing Forest Practice Rule requirements is shown in Table 14, beginning on the next page. For watercourse crossings with implementation evaluations, 64% had all the crossing rules rated as meeting or exceeding Forest Practice Rule requirements; 19% had one or more marginally acceptable ratings, but no departures; and 17% had one or more departures ratings (Figure 30).

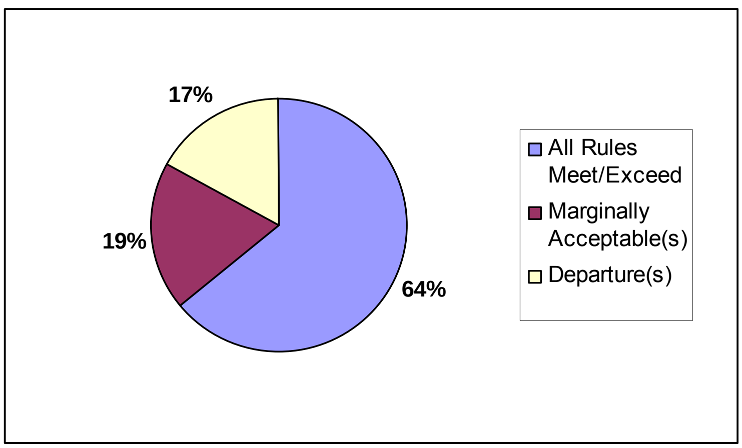

Figure 30. Percentages of watercourse crossings rated for Forest Practice Rule implementation having different implementation codes.

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[6] The minimum value of 30 observations (where the Forest Practice Inspector assigned a rating of D, MA, A, or ER) is similar to the value used in the earlier Hillslope Monitoring Program final report (Cafferata and Munn 2002), and represents nearly 10% of the possible implementation ratings available for each rule requirement.

[7] As shown in Table 14, 14 CCR § 923.3(a) has the overall highest rate of departure at 9.6%, but this rule only applies to new permanent crossings and temporary crossings within the WLPZ. Since it was rated as a departure for 18 existing culverts, it was concluded that spurious data was recorded for this requirement and it is not included.

Table 14. All Forest Practice Rule requirements rated for implementation (NA = Not Applicable).

Rule Number	Rule Description	Total Obs. (w/o NA)	Departure (%)	Departure + Marginally Acceptable (%)
923.2(d)(C) 943.2(d)(C) 963.2(d)(C)	Fills across channels built to minimize erosion	262	1.9	9.9
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to carry runoff	287	2.4	8.0
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to minimize erosion	285	2.8	8.4
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to maintain or restore the natural drainage pattern	287	2.4	7.7
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	65	6.2	23.1
923.2(o) 943.2(o) 963.2(o)	No discharge onto fill unless energy dissipators installed	255	2.4	14.1
923.3(a) 943.3(a) 963.3(a)	Permanent new crossings shown on THP map	188	9.6	11.7
923.3(c) 943.3(c) 963.3(c)	Unrestricted passage of fish allowed	21	4.8	4.8
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to adequately reform channel	94	7.4	21.3
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Removed crossings-- cut bank sloped back to prevent slumping and minimize soil erosion	95	3.2	11.6
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Where needed, stabilizing treatment applied	200	2.0	10.0
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	301	5.0	18.3
923.4(c) 943.4(c) 963.4(c)	Waterbreaks maintained as specified in 14 CCR 914.6	240	3.8	14.2
923.4(d) 943.4(d) 963.4(d)	Crossing open to unrestricted passage of water	316	3.5	12.3
923.4(d) 943.4(d) 963.4(d)	Trash racks installed where needed at inlets	125	3.2	12.0
923.4(f) 943.4(f) 963.4(f)	50-year flood flow requirement met or removed	228	2.2	7.5

Table 14 (continued.) All Forest Practice Rule requirements rated for implementation (NA = Not Applicable).

Rule Number	Rule Description	Total Obs. (w/o NA)	Departure (%)	Departure + Marginally Acceptable (%)
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	127	4.7	11.0
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	130	5.4	19.2
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	246	6.9	18.7
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	35	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	35	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills appropriate	35	5.7	8.6
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	36	5.6	11.1
923.8(d) 943.8(d) 963.8(d)	Abandoned crossings—pulling/shaping of fills appropriate	31	3.2	9.7
923.8(e) 943.8(e) 963.8(e)	Abandoned crossings—fills excavated to reform channel	35	2.9	20.0
923.8(e) 943.8(e) 963.8(e)	Abandoned crossings—cutbanks sloped back	30	3.3	6.7
923.8(e) 943.8(e) 963.8(e)	Abandon crossings—removal not feasible but diversion potential addressed	12	0.0	16.7
914.8(b) 934.8(b) 954.8(b)	Drainage structure used where water present during life of crossing	6	0.0	0.0
914.8(c) 934.8(c) 954.8(c)	Unrestricted fish passage in Class I watercourses	1	0.0	0.0
914.8(d) 934.8(d) 954.8(d)	Skid road crossing fill removed and banks sloped properly	23	4.3	8.7

Existing Culverts

Nineteen FPRs related to existing culverts were rated. These 19 FPRs do not include FPRs related to removed/ abandoned culverts and skid road culverts. Sixteen of these 19 FPRs were observed at 30 or more existing watercourse crossings. Nine of the 16 FPRs with 30 or more observations had departure rates of 4% or more, as shown in Table 15. For existing culverts, the FPR rule with the highest departure rate was 14 CCR § 923.4 [943.4, 963.4] (n), which requires crossings and their approaches to be maintained to avoid diversion of flow should the pipe become plugged. Other FPRs with high departure rates include FPRs requiring: 1) installation/maintenance of trash racks to minimize blockage (where required), 2) repair and replacement of crossing inlet and outlet structures, 3) maintenance of crossing openings for unrestricted passage of water, 4) waterbreak maintenance, and 5) culvert sizing for the required flood flow recurrence interval or removal of undersized culverts by the start of the winter period.

Table 15. Watercourse crossing related Forest Practice Rule requirements for existing culverts with at least four percent departures based on at least 30 observations (i.e., 20% of sample size) where implementation could be rated (i.e., excludes N/A observations).

Rule Number	Rule Description	Departure (%)	Departure plus Marginally Acceptable (%)
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to avoid diversion	12.4	27.8
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	11.4	37.1
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	7.5	17.9
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	7.2	23.2
923.4(d) 943.4(d) 963.4(d)	Trash racks installed where needed at inlets	6.8	27.3
923.4(d) 943.4(d) 963.4(d)	Crossing open to unrestricted passage of water	6.5	17.4
923.4(c) 943.4(c) 963.4(c)	Waterbreaks maintained as specified in 14 CCR 914.6	6.3	22.1
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	6.1	23.5
923.4(f) 943.4(f) 963.4(f)	Crossing meets 50-yr flood flow requirement or is removed by first day of the winter period	4.4	13.3

New Culverts

For culverts installed as part of the THP, only one rule requirement was found with greater than a 4% departure rate. 14 CCR § 923.3 [943.3, 963.3] (f), which requires crossings and associated fills to be constructed and maintained to prevent diversion, had a departure rate of 4.1% and a departure plus marginally acceptable rate of 13.7%.

Non-Culvert Crossings and Removed/Abandoned Crossings

Non-culvert crossings and removed/abandoned crossings were combined for rating FPR implementation because, in many cases, rules related to crossing removal were also rated for existing non-culvert crossings. This occurred since some removed crossings are fords that are drivable with four-wheel drive vehicles—and hence were considered existing crossings. Thirty FPR requirements were applicable to this combined category.

Of 20 FPRs with at least 26 observations (i.e., 20 percent of the sample size), 13 FPRs had a departure rate of 4% or higher, as shown in Table 16 (next page). The rule with the highest departure rate was 14 CCR § 923.2 [943.2, 963.2] (h), which requires the installation of drainage structures that are of sufficient size, number and location to carry runoff water in a manner that minimizes erosion, ensures proper functioning, and maintains or restores the natural drainage pattern. Additional FPRs with at least 4% departure rates specify that: 1) fills across channels must be constructed in a manner that minimizes erosion, 2) drainage structures do not discharge water onto fill without energy dissipators, and 3) crossings/approaches must be built and maintained to prevent diversion.

The removal and abandonment rule requirement with the highest overall departure rate was 14 CCR § 923.3 [943.3, 963.3] (d)(1), which specifies that fills for removed crossings must be excavated to form a channel that is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel. 14 CCR § 923.3 [943.3, 963.3] (d)(2), requiring removed crossings to have cut banks that are sloped back from the channel and stabilized to prevent slumping and minimize soil erosion, had a slightly lower departure rate. Other rule requirements with at least 4% departure rates were: 14 CCR § 923.8 [943.8, 963.8], which requires, among other items, that abandoned crossings provide permanent maintenance-free drainage and minimize the concentration of runoff; 14 CCR § 923.8 [943.8, 963.8] (b), which states that exposed soil on cut and fill slopes of abandoned crossings must be stabilized; and 14 CCR § 923.8 [943.8, 963.8] (c), requiring abandoned crossings to be graded and shaped in a manner that disperses water flow.

Bridges

No departures were assigned to the few bridges evaluated as part of the MCR monitoring work, and there was only one marginally acceptable rating. The FPR requirement 14 CCR § 923.4 [943.4, 963.4] (c), which specifies that waterbreaks on roads are to be maintained as specified under 14 CCR § 914.6 [934.6, 954.6], was cited once as being marginally acceptable for the road segments draining to the bridge.

Table 16. Forest Practice Rule requirements for non-culvert and removed/abandoned crossings with at least four percent departures based on at least 26 observations (i.e., 20% of sample size).

Rule Number	Rule Description	Percent Departure	% Departure plus Marginally Acceptable
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures minimizes erosion	8.8	20.6
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to reform a channel similar to the natural channel grade, but wider	7.5	26.9
923.2(h) 943.3(h) 963.3(h)	Size, number, location of drainage structures sufficient to carry runoff	6.5	13.0
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills	5.7	8.6
923.3(d)(1) 943.3(d)(1)	Fills across channels built to minimize erosion	5.6	22.2
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	5.6	11.1
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Removed crossings—cut bank slope	4.8	17.7
923.2(o) 943.2(o) 963.2(o)	No discharge on fill without energy dissipators	4.6	23.1
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	4.4	15.4
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to maintain or restore the natural drainage pattern	4.3	13.0
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	4.0	16.0

Watercourse Crossing Effectiveness Results

Watercourse crossing effectiveness was evaluated by applying one of the following four ratings to 27 crossing-related parameters: not applicable (N/A), not a problem (usually "none" or "slight"), a minor problem, or a major problem.[8] Examples of crossings rated for effectiveness are shown in Figures 31 and 32. On nearly 25 percent of the 289 crossings rated for effectiveness, this evaluation was conducted one or more years after the implementation ratings were made. The rest of the crossings with effectiveness ratings were evaluated for implementation and effectiveness at the same, or nearly the same, time. Table 17 shows the percentage of major and minor problems when all crossing types are combined. The percentage of crossings with major and minor problems for different combinations of crossing types, crossing features, and problem types is displayed in Table 18.

Figure 31. Example of an existing culvert with scour at the outlet for a central Sierra Nevada THP included in the MCR sample.

Figure 32. Example of an existing culvert that is partially plugged with sediment on a central Sierra Nevada THP included in the MCR sample.

[8] For rutting, N/A was not provided on the field form. For culvert-related piping, the minor category was not provided as an option. The N/A option was not provided for any of the effectiveness parameters on the initial field form provided at the beginning of the MCR monitoring program.

Table 17. Watercourse crossing effectiveness ratings (excludes NA ratings).

Crossing Feature	Problem Type	Total # (w/out NA)	Major Only (%)	Major + Minor (%)
Fill Slopes	Gullies	253	1.2	11.5
	Cracks	253	0.0	2.4
	Slope Failure	254	1.2	5.1
Road Surface Draining		0	0.0	0.0
To Crossing	Gullies	272	0.4	6.3
	Cutoff Drainage Structure	225	4.0	24.9
	Inside Ditch Condition	119	0.8	18.5
	Ponding	261	0.0	12.6
	Rutting	248	0.8	16.5
Culvert Crossing	Scour at Inlet	182	1.1	15.9
	Scour at outlet	182	1.1	33.5
	Diversion Potential	179	10.6	35.2
	Plugging	182	5.5	17.6
	Alignment	180	1.7	5.6
	Degree of Corrosion	169	1.8	7.7
	Crushing	181	0.6	5.0
	Pipe length	182	0.0	4.9
	Gradient	182	2.7	8.2
	Piping	180	2.2	2.2
Non-Culverted Crossing	Armoring	58	1.7	32.8
	Scour at outlet	71	0.0	43.7
	Diversion Potential	73	5.5	23.3
Abandoned/Removed	Bank stabilization	36	0.0	22.2
	Gullies	36	0.0	8.3
	Slope Failure	16	0.0	0.0
	Channel Configuration	38	7.9	28.9
	Excavated Material	33	0.0	12.1
	Maintenance Free Drainage	45	0.0	17.8

Table 18. Modified Completion Report—Watercourse Crossing Effectiveness Ratings (% major, % minor, % major + minor) [excludes NA ratings].

Crossing Feature	Problem Type	Existing Culverts	New Culverts	Non-Culvert	Removed/Abandoned	Bridge
Fill Slopes	Gullies	2.6/ 8.7/ 11.3	0/ 10.0/ 10.0	0/17.2/ 17.2	NA	0/ 0/ 0
	Cracks	0/ 2.4/ 2.4	0/ 3.9/ 3.9	0/ 1.8/ 1.8	NA	0/ 0/ 0
	Slope Failure	1.6/ 3.2/ 4.8	1.9/ 1.9/ 3.8	0/ 8.8/ 8.8	NA	0/ 0/ 0
Road Surface Draining to Crossing	Gullies	0.8/ 4.9/ 5.7	0/ 0/ 0	0/ 10.7/ 10.7	0/ 11.1/ 11.1	0/ 0/ 0
	Cutoff Drainage Structure	6.5/ 27.8/ 34.3	2.1/ 23.4/ 25.5	2.0/ 12.0/ 14.0	0/ 0/ 0	0/ 0/ 0
	Inside Ditch Condition	1.4/ 20.3/ 21.7	0/ 8.0/ 8.0	0/ 26.7/ 26.7	0/ 0/ 0	0/ 25.0/ 25.0
	Ponding	0/ 13.5/ 13.5	0/ 18.0/18.0	0/ 9.4/ 9.4	0/ 6.3/ 6.3	0/ 0/ 0
Culvert	Scour at Inlet	1.6/ 16.3/ 17.8	0/ 11.3/ 11.3	NA	NA	NA
	Scour at outlet	1.6/ 36.4/ 38.0	0/ 22.6/ 22.6	NA	NA	NA
	Diversion Potential	11.9/ 26.2/ 38.1	7.5/ 20.8/ 28.3	NA	NA	NA
	Plugging	7.8/ 14.0/ 21.7	0/ 7.5/ 7.5	NA	NA	NA
	Alignment	1.6/ 4.7/ 6.3	1.9/ 1.9/ 3.8	NA	NA	NA
	Degree of Corrosion	2.4/ 8.1/ 10.6	0/ 0/ 0	NA	NA	NA
	Crushing	0.8/ 5.5/ 6.3	0/ 1.9/ 1.9	NA	NA	NA
	Pipe length	0/ 5.4/ 5.4	0/ 3.8/ 3.8	NA	NA	NA
	Gradient	3.8/ 7.7/ 11.5	0/ 0/ 0	NA	NA	NA
	Piping	3.1/ 0/ 3.1	0/ 0/ 0	NA	NA	NA
Non-Culverted Crossing	Armoring	NA	NA	1.8/ 32.1/ 33.9	0/ 0/ 0	NA
	Scour at outlet	NA	NA	0/ 42.6/ 42.6	0/ 66.7/ 66.7	NA
	Diversion Potential	NA	NA	4.3/ 18.6/ 22.9	33.3/ 0/ 33.3	NA
Removed/Abandoned	Bank stabilization	NA	NA	0/ 21.4/ 21.4	0/ 22.7/ 22.7	NA
	Gullies	NA	NA	0/ 6.3/ 6.3	0/ 10.0/ 10.0	NA
	Slope Failure	NA	NA	0/ 0/ 0	0/ 0/ 0	NA
	Channel Configuration	NA	NA	12.5/ 37.5/ 50.0	4.5/ 9.1/ 13.6	NA
	Excavated Material	NA	NA	0/ 33.3/ 33.3	0/ 0/ 0	NA
	Maintenance Free Drainage	NA	NA	0/ 21.7/ 21.7	0/ 13.6/ 13.6	NA

All Crossing Types

When all crossing types are combined, major problems were found a total of 76 times on 53 crossings. The most frequently cited effectiveness problems were associated with culvert diversion potential (19), followed by culvert plugging (10), and road cutoff drainage structure function (9) (see Figure 33). Other parameters identified as having major problems four or more times included: culvert gradient, culvert piping, and non-culvert crossing diversion potential. Overall, 18% of the crossings evaluated for effectiveness had one or more major problems.

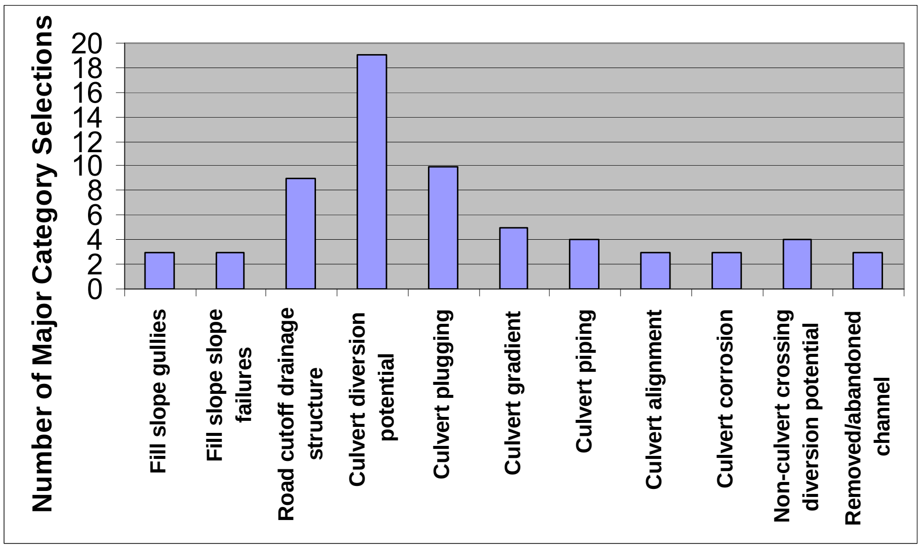

Figure 33. Major problem effectiveness categories for all crossing types.

When the major and minor problem categories were combined, the most frequently cited feature remained culvert diversion (63 selections), but secondary parameters were somewhat different. They included: culvert scour at the outlet (61), road cut-off waterbar function (56), road rutting (41), road ponding (33), culvert plugging (32), and non-culvert crossing scour at the outlet (31).

For new and existing culverts, 10.6% had a major diversion problem, 5.5% had a major plugging concern, 4.0% had a cutoff drainage structure problem, 2.7% had a significant gradient issue, and 2.2% had a major piping concern. For non-culverted crossings, 5.5% had a major diversion potential problem (Table 17).

Existing Culverts

For existing culverts, 11.9% of the pipes had a major problem with diversion potential, while 7.8% had a major problem with inlet or outlet plugging, as shown in Table 18. Road cut-off drainage structures were identified as a major problem for 6.5% of the crossings, and approximately 3% of the road fills at crossings had significant gullying present. For combined major and minor effectiveness ratings, the following features were selected greater than 30% of the time: culvert scour at the outlet (38.0%), culvert diversion potential (38.1%), and road cutoff drainage structure (34.3%). Culvert plugging and road inside ditch condition were selected more than 20% of the time for both effectiveness ratings.

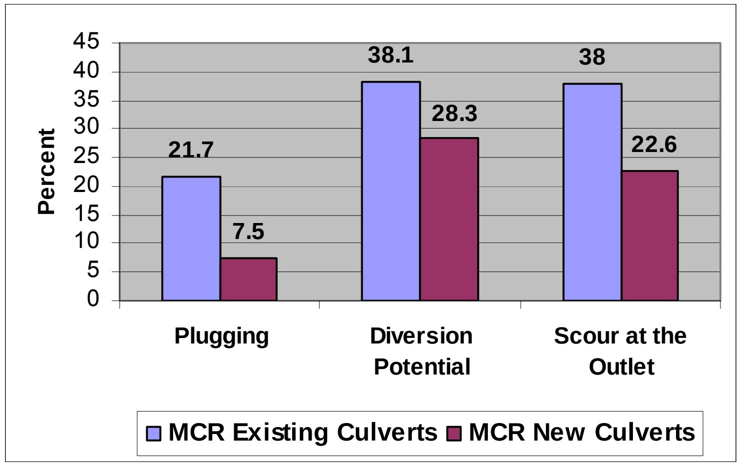

Figure 34. Comparison of three culvert effectiveness categories for new culverts installed as part of the THP vs. existing culverts installed before the plan. Data shown is for both major and minor effectiveness categories combined.

New Culverts

The percentage of major and minor problems was smaller for new culverts that were installed as part of the most recent THP, when compared to existing culverts. This can be attributed to improved practices and/or fewer overwintering periods with stressing storm events (Figure 34). As displayed in Table 18, 7.5% of the new culverts had significant diversion potential, 2.1% had major problems with road cutoff drainage structures, and 1.9% had major problems with culvert alignment and fill slope failures. For combined major and minor effectiveness ratings, the following features were found to have problems more than 20% of the time: culvert diversion potential (28.3%), culvert scour at the outlet (22.6%), and road cutoff drainage structures (25.5%).

Non-Culvert and Removed/Abandoned Crossings

There were major diversion potential problems on 4.3% of the non-culvert crossings and minor problems on an additional 18.6%, for a combined total of 22.9%. For both removed/abandoned crossings and non-culvert crossing types, channel configuration following crossing removal had the highest percentage of problems, with 7.9% of the crossings rated as having a major problem and 21.0% receiving a minor problem, for a combined rating of 28.9%.

Bridges

None of the five bridges rated for effectiveness had any major problems identified. The condition of the road inside ditch was selected once as a minor problem.

III. Discussion

Watercourse crossing implementation ratings are generally similar to findings from the earlier HMP (Cafferata and Munn 2002). For example, the departure rates in the HMP for 14 CCR § 923.3 [943.3, 963.3] (f) [requiring construction to prevent diversion] were 5.5% major departures and 14.6% major plus minor departures, respectively; which are similar to the 5.0% and 18.3% rates for departure and departure plus marginally acceptable ratings in the MCR work.[9] Additionally, abandonment rules 14 CCR § 923.8 [943.8, 963.8], 923.8 [943.8, 963.8] (b), and 923.8 [943.8, 963.8] (c) in the HMP had major departure rates of 4.6%, 4.8%, and 4.8%, respectively, while the MCR monitoring results for these rules had departure rates of 5.7%, 5.7%, and 5.6%. The FPRs 14 CCR § 923.3 [943.1, 963.1] (d)(1), 923.4 [943.4, 963.4] (l), and 923.4 [943.4, 963.4] (n) were also listed as having relatively high departure rates in both monitoring programs. In addition, in the final HMP data set (1996 through 2002), one or more major rule departures were found for 19.5% of the watercourse crossings, compared to 17% of crossings with departures in the MCR work.

Similarly, MCR watercourse crossing effectiveness results compare well with the findings of previous watercourse crossing studies in California, both with studies done on private and state lands (HMP) and studies done on federal National Forest System (NFS) lands (Figure 35). For example, the HMP (Cafferata and Munn 2002) reported that 9.0% of culverted crossings had major diversion potential problems, which compares well with the 10.6% rate reported in this study based on analysis of MCR data (see Figure 36 for an example of a crossing without diversion potential). Both the HMP and MCR monitoring sampled sites on private and state lands in California, and as such are directly comparable. The USFS (2004) BMP Evaluation Program sampled federal (NFS) lands in California and found major diversion problems on 8.9% of culverted crossings, which is also compares well with both the HMP (9.0%) and MCR (10.6%) results. For culvert plugging, the HMP and USFS BMP documents reported problems on 8.6% and 3.0% of crossings, respectively, while the rate is 5.5% based on the MCR data. Data for scour at the outlet of a culvert is less consistent between these three recent monitoring programs, probably due to differing instructions and definitions.[10] A more detailed comparison of the HMP and MCR crossing effectiveness data is provided in Table 19.

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[9] FPR 14 CCR § 923.3(f) is referred to in Cafferata and Munn (2002) as 923.3(e).

[10] For example, in the HMP major scour at the outlet was defined as extending more than two channel widths below the pipe outlet, or scour that is undercutting the crossing fill, while in MCR monitoring, it was simply defined as “major scour, maybe undercutting fill material.”

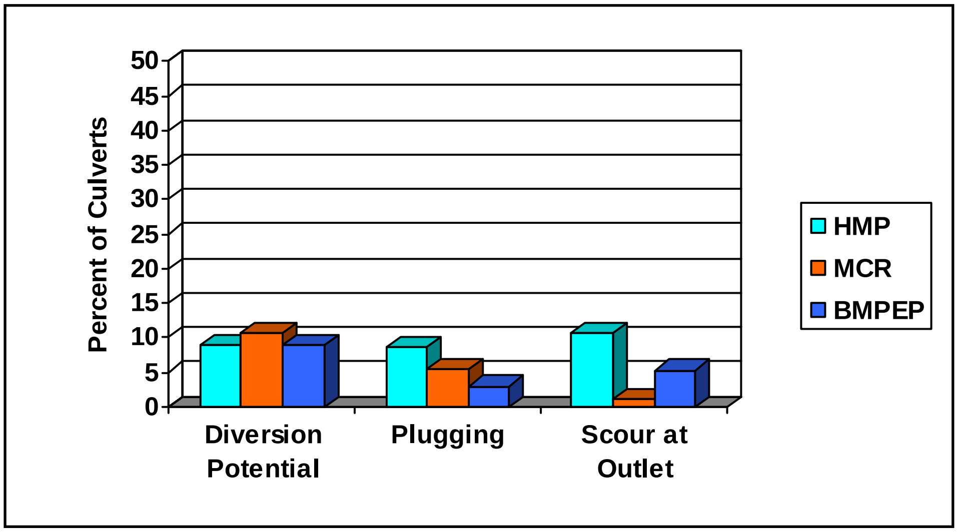

Figure 35. Comparison of three Modified Completion Report (MCR) culvert crossing effectiveness categories to results from the Hillslope Monitoring Program (HMP) and USFS BMP Evaluation Program. Ratings are for major effectiveness categories for the HMP and MCR programs.

Table 19. Comparison of MCR and HMP crossing effectiveness data for selected categories.

Monitoring Program	Culvert Plugging	Culvert Diversion Potential	Culvert Scour At the Outlet	Removed/Abandoned Channel Configuration
MCR Problems				
Major	5.5 %	10.6%	1.1%	7.9%
Minor	12.1%	24.6%	32.4%	21.0%
Total	17.6%	35.2%	33.5%	28.9%
HMP Problems				
Major	8.6%	9.0%	10.7%	3.6%
Minor	14.9%	18.5%	22%	14.3%
Total	23.5%	27.5%	32.7%	17.9%

Figure 36. John Munn, CDF, at a culverted watercourse crossing in a forested watershed on the North Coast of California without diversion potential. Munn is standing in the critical dip.

Conclusions and Recommendations

Overall Findings and Recommendations

Findings: Overall, the Modified Completion Report monitoring work found that:

1) The rate of compliance with FPRs designed to protect water quality and aquatic habitat is generally high, and
2) FPRs are highly effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented.

Recommendations: The Forest Practice Program should continue to emphasize education, licensing, inspection and enforcement to ensure proper implementation of the FPRs designed to protect water quality. Since departures from the FPRs were found to be rare, the best inspection strategy is to have the inspectors focus on THPs and locations where their experience and previous plan review indicate that problems are most likely to occur. After a quick prioritization, inspectors should visually observe as much ground as possible to maximize detection of departures from FPRs, which are important but uncommon occurrences.

Because straightforward, clearly stated rules are more likely to be properly implemented, they are more likely to protect water quality. They are also easier to inspect, enforce and monitor. Therefore, the BOF should avoid unnecessary complexity and ambiguous language when revising or adding to the existing FPRs.

MCR monitoring should be revised according the specific recommendations for WLPZs, roads and watercourse crossings, which are outlined below.

Watercourse and Lake Protection Zones (WLPZs) Findings and Recommendations

Findings: With few exceptions, Watercourse and Lake Protection Zone (WLPZ) canopy and groundcover met Forest Practice Rule (FPR) standards. Patches of bare soil in WLPZs exceeding the FPR standards are rare, erosion features within WLPZs related to current operations are uncommon, and there are few instances where WLPZ canopy standards are not being met. Prevention, detection and abatement of these rare occurrences is an important key to improving water quality protection.

Recommendations: The Forest Practice Program should emphasize prevention, detection and abatement of WLPZ problems through rapid ocular inspections of WLPZs. The use of time-consuming canopy and ground cover measuring techniques should be reserved for enforcement where a rapid inspection has detected WLPZ canopy and/or groundcover conditions that may not meet minimum standards set by the FPRs or special provisions of the THP.

To provide more time for rapid ocular inspections, WPLZ trend monitoring conducted by Forest Practice Inspectors, such as with MCR inspections, should use the smallest random sample size that will produce repeatable and reliable results. As a starting point, a WLPZ sample size of 5 percent of all THPs undergoing Work Completion Report Inspections is recommended. This may then be adjusted up or down annually based on an analysis of the prior year's data.

The current MCR data collection methods and procedures for WLPZs work well and, with some minor revisions to the WLPZ form, are suitable for use in the next phase of MCR Monitoring.

Road Findings and Recommendations

Findings: Properly implemented Forest Practice Rules are highly effective in preventing road erosion and sediment transport from roads to channels. Erosion and sedimentation is more likely to occur at road-related features where the implementation of the applicable FPR(s) is only marginally acceptable. Erosion and sediment transport are much more likely at road-related features where there was a departure from the applicable FPR(s) (See Table 7 on page 40). For example, at sites where there is a departure from the rule, the chance of erosion is about 1 in 2, the chance sediment transport is about 1 in 3, and the chance of sediment transport to a channel 1 in 10. In comparison, where FPR implementation is acceptable or better, the chance of erosion is about 1 in 20, and the chance of sediment transport to a channel is 1 in 100 or less.

Drainage problems (including drainage feature spacing, design, construction and maintenance) and failure to discharge into non-erodible cover are the most frequent types of departures from the road-related FPRs. Specifically, the following four categories of FPRs accounted for 95% of the departures: waterbreak spacing [49%], drainage ditches maintained/berms removed [17%], waterbreak discharge into cover [16%], and waterbreaks constructed to appropriate depth [13%]. These departures from the rules are also the most frequent causes of road-related erosion and sediment transport to channels.

Departure rates for the road-related features were 2% for the Coast (Region 1) and 8% for the Inland Area (Regions 2 &4). Most of these departures are clustered in a few poorly built and/or poorly maintained road segments. For example, just 6% of the sampled road segments, which would represent about sixth-tenths of a mile in 10 road miles, accounted for half the departures on Coast THPs and about three-quarters of the departures on Inland THPs.

The current MCR data collection methods and procedures for roads were found to be cumbersome, and both implementation and enforcement could be improved by focusing on two items critical to water quality protection: 1) the spacing and adequacy of the drainage features and, 2) discharge of road drainage into cover or non-erodible sites. These results are based on drainage spacing evaluations conducted during field inspections. No secondary analysis of drainage spacing could be conducted because FPR drainage spacing requirements are based on the Erosion Hazard Rating (EHR) and the road grade between drainage features, but these two pieces of data were not recorded on the MCR road form.

Recommendations: The Forest Practice Program should continue to emphasize proper implementation of the road-related FPRs through education and enforcement. Streamlining and consolidating the road-related rules to make them easier to understand, implement and enforce is expected to improve FPR effectiveness in protecting water quality.

Finding and fixing the worst 6% of THP road segments would yield the largest improvement in THP road-related water quality protection.   The Forest Practice Program should encourage landowners, Registered Professional Foresters (RPFs) and Licensed Timber Operators (LTOs) to find and repair these problem sites. A standard, recommended methodology for finding and fixing the worst 6% of THP road segments may prove useful and could be developed by a subcommittee of the BOF, such as the MSG.

In addition, the current MCR data collection procedures should be revised to account for the types of water quality problems most commonly found on roads. Focus should be placed on: 1) the spacing and adequacy of drainage features and, 2) discharge of road drainage into cover or non-erodible sites. To allow a secondary check of appropriate drainage spacing according to the FPRs, the data collected for each road segment should also include the grade between drainage features (as measured in the field with a clinometer) and the Erosion Hazard Rating (EHR) assigned to the portion of the THP that includes the road segment.

Watercourse Crossing Findings and Recommendations

Findings: A total of 357 watercourse crossings were rated for FPR implementation. Approximately 62% of these were culverts, 25% were fords, 11% were removed or abandoned crossings, and 2% were bridges. Almost 60% of the crossings were in Class III watercourses, and close to 75% were associated with seasonal roads.

Ten FPR requirements (out of 30 rated) were found to have departure rates of 4% or higher. Five of these ten FPRs related to removed or abandoned crossings. The one rule with the highest departure rate (7.4%) requires fills to be excavated to form a channel that is similar to the natural watercourse grade and orientation and is wider than the natural channel.

For crossings with implementation evaluations, 64% had all the crossing rules rated as meeting or exceeding the FPRs; 19% had one or more marginally acceptable ratings, but no departures; and 17% had one or more departure rating(s). This compares well with the earlier HMP results, which had 19.5% of the crossings with one or more major departures.

Out of the twenty-seven items rated on each of the 289 crossings evaluated for crossing effectiveness, major problems were found a total of 76 times on 53 crossings (i.e., 18% of the crossings had significant effectiveness problems). For all new and existing culverts, 10.6% had a major diversion problem, 5.5% had a major plugging concern, and 4.0% had a major cutoff drainage structure problem. The percentage of major and minor problems was smaller for new culverts installed as part of the current THP when compared to existing culverts.

Recommendations: The Forest Practice Program should re-emphasize, through both education and enforcement, proper implementation of five aspects of culvert design, installation and maintenance included in the FPRs:

1. Proper design for passage of wood and sediment, as well as 100-years flood flows (Cafferata and others 2004),
2. Installation of functional critical dips at culvert crossings (Weaver and Hagans 1994),
3. Installation and maintenance of cutoff-drainage structures designed to prevent direct discharge to watercourse channels and erosion of crossing fills (Figure 37),
4. Proper maintenance to prevent plugging from wood and sediment, and
5. The complete excavation of fills at removed crossings to form a channel that is similar to the natural watercourse grade and orientation and is wider than the natural channel.

Figure 37. Pete Cafferata, CDF, points to the outlet of a uniquely-designed 3-rail cutoff-drainage structure on the approach to a watercourse crossing located in a forested watershed on the North Coast of California. Features like this, commonly a rolling dip without the rails, are used to prevent direct discharge of road runoff into watercourse channels.

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Glossary

Abandonment – Leaving a logging road reasonably impassable to standard production four-wheel-drive highway vehicles, and leaving a logging road and landings, in a condition which provides for long-term functioning of erosion controls with little or no continuing maintenance (14 CCR § 895.1).

Alternative practice – Prescriptions for the protection of watercourses and lakes that may be developed by the RPF or proposed by the Director of CDF on a site-specific basis provided that several conditions are complied with and the alternative prescriptions will achieve compliance with the standards set forth in 14 CCR § 916.3 (936.3, 956.3) and § 916.4(b) [(936.4(b), 956.4(b)]. 14 CCR § 916.6 (936.6, 956.6) More general alternative practices are permitted under 14 § CCR 897(e).

Beneficial uses of water - As described in the Porter-Cologne Water Quality Control Act, beneficial uses of water include, but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish and wildlife, and other aquatic resources or preserves. In Water Quality Control Plans, the beneficial uses designated for a given body of water typically include: domestic, municipal, agricultural, and industrial supply; industrial process; water contact recreation and non-water contact recreation; hydropower generation; navigation; groundwater recharge; fish spawning, rearing, and migration; aquatic habitat for warm-water species; aquatic habitat for coldwater species; and aquatic habitat for rare, threatened, and/or endangered species (Lee 1997).

Best management practice (BMP) - A practice or set of practices that is the most effective means of preventing or reducing the generation of nonpoint source pollution from a particular type of land use (e.g., silviculture) that is feasible, given environmental, economic, institutional, and technical constraints. Application of BMPs is intended to achieve compliance with applicable water quality requirements (Lee 1997).

Canopy - the foliage, branches, and trunks of vegetation that blocks a view of the sky along a vertical projection. The Forest Practice Rules define canopy as “the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody species” (14 CCR § 895.1).

Critical dip – a dip over or near a culverted watercourse crossing designed to minimize the loss of road fill and the subsequent discharge of sediment into the affected watercourse in the event the culvert plugs.

Cutbank/sidecast sloughing – Shallow, surficial sliding associated with either the cutbank or fill material along a forest road or skid trail, with smaller dimensions than would be associated with mass failures.

Exception – A non-standard practice for limitations on tractor operations, 14 CCR § 914.2(f)(3) [934.2(f)(3), 954.2(f)(3)].

Gully - Erosion channels deeper than 6 inches (no limitation on length or width). Gully dimensions were estimated.

In-lieu practice – These practices apply to FPR sections for watercourse protection where provision is made for site-specific practices to be proposed by the RPF, approved by the Director and included in the THP in lieu of a stated Rule. The RPF must reference the standard Rule, explain and describe each proposed practice, how it differs from the standard practice, indicate the specific locations where it will be applied, and explain and justify how the protection provided by the proposed practice is at least equal to the protection provided by the standard Rule 14 CCR § 916.1 [936.1, 956.1].

Mass failure – Downslope movement of soil and subsurface material that occurs when its internal strength is exceeded by the combination of gravitational and other forces. Mass erosion processes include slow moving, deep-seated earthflows and rotational failures, as well as rapid, shallow movements on hillslopes (debris slides) and in downstream channels (debris torrents).

Non-standard practice - A practice other than a standard practice, but allowable by the FPR as an alternative practice, in-lieu practice, waiver, exclusion, or exemption (Lee 1997).

Permanent road – A road which is planed and constructed to be part of a permanent all-season transportation facility. These roads have a surface which is suitable for the hauling of forest products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the 50-year flow. Normally they are maintained during the winter period (14 CCR 895.1). After July 1, 2000, watercourse crossings associated with permanent roads have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Process - The procedures through which the FPRs/BMPs are administered and implemented, including: (a) THP preparation, information content, review and approval by RPFs, Review Team agencies, and CDF decision-makers, and (b) the timber operations completion, oversight, and inspection by LTOs, RPFs, and CDF inspectors (Lee 1997).

Quality assurance - The steps taken to ensure that a product (i.e., monitoring data) meets specified objectives or standards. This can include: specification of the objectives for the program and for data (i.e., precision, accuracy, completeness, representativeness, comparability, and repeatability), minimum personnel qualifications (i.e., education, training, experience), training programs, reference materials (i.e., protocols, instructions, guidelines, forms) for use in the field, laboratory, office, and data management system (Lee 1997).

Quality control - The steps taken to ensure that products which do not meet specified objectives or standards (i.e., data errors and omissions, analytical errors) are detected and either eliminated or corrected (Lee 1997).

Repeatability – The degree of agreement between measurements or values of a monitoring parameter made under the same conditions by different observers (Lee 1997).

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997). Forest Practice Rules are included in Title 14 of the California Code of Regulations (14 CCR).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (14 CCR § 895.1). After July 1, 2000, all permanent watercourse crossings have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Standard practice - A practice prescribed or proscribed by the Rules (Lee 1997).

Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (14 CCR § 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (14 CCR § 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted. Waterbreaks are synonymous with waterbars (14 CCR § 895.1).

Watercourse – Any well-defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel or soil including but not limited to , streams as defined in PRC 4528(f). Watercourse also includes manmade watercourses (14 CCR § 895.1).

Watercourse class - Classification of watercourses into one four groups (Classes I, II, III and IV) is based characteristics or key indicators of beneficial uses as described in 14 CCR § 916.5 (936.5, 956.5).

- Class I watercourses include: 1) Domestic supplies, including springs, on site and/or within 100 feet of downstream of the operations area and/or, 2) Fish always or seasonally present onsite, includes habitat to sustain fish migration and spawning.
- Class II watercourses include: 1) Fish always or seasonally present offsite within 1000 feet downstream and/or 2) Aquatic habitat for nonfish aquatic species. Excludes Class III waters that are tributary to Class I waters.
- Class III watercourses include: 1) No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.
- Class IV watercourses include: Manmade watercourses, usually downstream, established domestic, agricultural, hydroelectric supply, or other beneficial uses.

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997). Forest Practice Rules are included in Title 14 of the California Code of Regulations (14 CCR).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (14 CCR 895.1). After July 1, 2000, all permanent watercourse crossings have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

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Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (14 CCR 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (14 CCR 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted. Waterbreaks are synonymous with waterbars (14 CCR 895.1).

Appendix A:

Modified Completion Report Methods and Procedures

(revised April 9, 2003)

An electronic copy of the *Modified Completion Report Monitoring Procedures and Methods (rev.4/9/03)* is available on line at:

http://www.bof.fire.ca.gov/board/msg_archives.asp

MONITORING STUDY GROUP
CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

HILLSLOPE MONITORING PROGRAM

MONITORING RESULTS FROM 1996 THROUGH 2001

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State of California

DECEMBER 2002
SACRAMENTO, CALIFORNIA
BOARD OF FORESTRY AND FIRE PROTECTION

HILLSLOPE MONITORING PROGRAM: MONITORING RESULTS FROM 1996 THROUGH 2001

December 2002

by Peter H. Cafferata and John R. Munn
California Department of Forestry and Fire Protection

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The Monitoring Study Group (MSG) is made up of members of the public, resource agencies (both state and federal), and the timber industry. The agencies listed above make up the MSG; the names listed above are the primary representatives for these agencies at MSG meetings. The MSG chair is appointed by the Board of Forestry and Fire Protection (BOF) and the group is staffed by CDF. Each agency and organization is responsible for determining the appropriate person to serve as a representative on the MSG (i.e., the BOF does not make formal appointments to the MSG).

Executive Summary

The Hillslope Monitoring Program has been evaluating the implementation and effectiveness of California forest practices since 1996. This project began with field inspection of 50 timber harvesting plans (THPs) in Humboldt and Mendocino Counties in 1996, and has continued with a statewide random sample of 50 plans in subsequent years. Non-industrial timber management plans (NTMPs) were added in 2001.

As part of the Program, detailed information has been collected during summer months on THPs that have gone through one to four winters after harvesting was completed. Site characteristics, erosion problems, and Forest Practice Rule (FPR) implementation were recorded for randomly located landings, watercourse crossings and for randomly selected road, skid trail, and watercourse protection zone segments. Data was also collected at the site of large erosion events that were identified in the THP or located while conducting the field work. Some information was recorded on non-standard practices and additional mitigation measures when they were applied at the study sites and transects. Observations of fine sediment transport during winter storms were not included in this program because of logistic and safety concerns. Additionally, evaluation of the THP review and inspection process was not included as part of the Hillslope Monitoring Program.

This report is based on the 295 THPs and 5 NTMPs sampled through 2001. About 63 percent of these plans were on large ownerships and 37 percent were classified as smaller ownerships (non-industrial timberlands and other types of ownerships). The Coast Forest Practice District contained 61 percent of the plans, while the Northern and Southern Districts had 26 and 13 percent, respectively. The monitoring data was collected and entered into an extensive database by experienced independent contractors who acted as third party auditors. An interim report of study findings was prepared for the California State Board of Forestry and Fire Protection in June 1999. This report updates the interim findings and offers several recommendations. Analysis completed on the data set to date has primarily been composed of frequency counts and has been limited by time and access to database analysts. Additional data analysis will be conducted in the future.

Implementation and effectiveness of the Forest Practice Rules were rated by the field team as conditions requiring application of the Rules were encountered on the study sites and transects, and as part of an overall evaluation following completion of the inspection. In both cases, implementation of the Rules applicable to a given subject area was rated as either exceeding the requirements of the Forest Practice Rules, meeting the requirements, minor departure from requirements, major departure from requirements, not applicable, could not determine, or could not evaluate (with a description of why). At erosion problem points, the source and cause of the feature was recorded, along with whether sediment had been transported to a watercourse.

Results to date show that implementation rates of the Forest Practice Rules related to water quality are high and that individual practices required by the Rules are effective in

preventing hillslope erosion features when properly implemented. Overall implementation ratings were greater than 90 percent for landings and for road, skid trail, and watercourse protection zone transects. Watercourse crossings had the lowest overall implementation ratings at 86 percent. Implementation of applicable Rules at problem points was nearly always found to be less than that required by the FPRs. These results, however, do not allow us to draw conclusions about whether the existing Rules are providing properly functioning habitat for aquatic species, since evaluating the biological significance of the current Rules was not part of the project.

To focus on areas where improvement in Rule implementation would provide the greatest benefit to water quality and where educational efforts are required, a list of 20 FPR requirements with the highest percentage of major departures is provided in the report. Three of these Rule requirements relate to roads, three to both roads and crossings, one to both roads and landings, one to skid trails, one to landings, ten to watercourse crossings, and one to watercourse protection zones.

Watercourse crossing problems are caused by a number of factors, including inherent uncertainties in determining and implementing site specific construction and abandonment needs, improper maintenance, the finite expected life of culverts, and high risk location for sediment delivery when stream discharge exceeds design discharge. The majority of the evaluated crossings were existing structures that were in place prior to the development of the THP, and frequent problems related to adequate design, construction, and maintenance were found. Crossings with culverts installed as part of the plan evaluated had a significantly lower rate of problem points per crossing, when compared to existing culverted crossings. Common problems included culvert plugging, stream diversion potential, fill slope erosion, scour at the outlet, and ineffective road surface cutoff waterbreaks.

The other main problem area identified by this program is erosion from roads caused by improper design, construction, and maintenance of drainage structures. Nearly half the road transects had one or more rills present and approximately 25 percent had at least one gully. Evidence of sediment transport to at least the high flow channel of a watercourse was found on 12.6 percent and 24.5 percent of the rill and gully features, respectively, with high percentages of delivery to Class III watercourses. These erosion features were usually caused by a drainage feature deficiency, and the FPRs rated at these problem sites were nearly always found to be out of compliance. Most of the identified road problems were related to inadequate size, number, and location of drainage structures; inadequate waterbreak spacing; and lack of cover at waterbreak discharge points. About six percent of the drainage structures evaluated along the road transects were found to have problems.

In contrast, watercourse protection zones were found to retain high levels of post-harvest canopy and surface cover, and to prevent harvesting related erosion. Mean total canopy exceeded FPR requirements in all three Forest Practice Districts and was approximately 80 percent in the Coast Forest Practice District for both Class I and II watercourses. Surface cover exceeded 75 percent for all watercourse types in the three districts. WLPZ width requirements were generally met, with major Rule departures recorded only about one percent of the time. The frequency of erosion events related to current operations in watercourse protection zones was very low for Class I, II, and III watercourses. Similarly, landings and skid trails were not found to be producing substantial impacts to water quality. Erosion problems on landing surfaces, cut slopes, and fill slopes were relatively rare. Rill and gully erosion features on skid trails were much less frequent than found on road transects, and sediment delivery to watercourses was also considerably lower.

Preliminary results on the use of non-standard practices and additional mitigation measures indicate the need for more thorough THP inspection to ensure proper implementation. A more focused monitoring approach, however, is needed to adequately examine the implementation and effectiveness of these practices. To date, the emphasis of the Hillslope Monitoring Program has been on evaluating the adequacy of standard Forest Practice Rules, and relatively little data has been collected for non-standard practices.

Ten recommendations are provided based on study findings to date. Six of these relate to training needs for CDF Forest Practice Inspectors, RPFs, Licensed Timber Operators, and personnel from other reviewing agencies (e.g., CDFG, CGS, and the Regional Water Quality Control Boards). Since watercourse crossings were found to be a significant problem area, voluntary, cooperative road management plans are recommended to effectively locate, prioritize, and schedule improvement work for high risk crossing structures. The results of this study also indicate a need to revise the Hillslope Monitoring Program to adequately sample additional mitigation measures and non-standard practices that are frequently added to THPs. Study revisions are also needed to monitor changes in the Forest Practice Rules that have occurred since July 1, 2000. Finally, it is recommended that the BOF and CDF continue to support the implementation and funding of instream monitoring projects designed to monitor compliance with Regional Water Quality Control Board Basin Plan standards.

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List of Abbreviations

ACL	Associated California Loggers
BMPs	Best management practices
BOF	California State Board of Forestry and Fire Protection
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CFA	California Forestry Association
CGS	California Geological Survey
CLFA	California Licensed Foresters Association
CPSS	Certified Professional Soil Scientist
CSES	Critical Sites Erosion Study
EEZ	Equipment exclusion zone
EHR	Erosion hazard rating
ELZ	Equipment limitation zone
ESU	Evolutionarily significant unit
FLOC	Forest Landowners of California
FPA	Forest Practice Act
FPRs	Forest Practice Rules
HMP	Hillslope Monitoring Program
LTMP	Long-Term Monitoring Program
LTO	Licensed Timber Operator
LWD	Large woody debris
MAA	Management Agency Agreement
MCR	Modified Completion Report
MSG	Monitoring Study Group
NMFS	National Marine Fisheries Service
NTMP	Nonindustrial Timber Management Plan
NCRWQCB	North Coast Regional Water Quality Control Board
NTO	NTMP Notice of Timber Operations
PHI	Pre-Harvest Inspection
PMP	Pilot Monitoring Program
QA/QC	quality assurance/ quality control
RCD	Resource Conservation District
RG	Registered Geologist
RPF	Registered Professional Forester
Rules	Forest Practice Rules
RWQCB	California Regional Water Quality Control Board
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
THP	Timber Harvesting Plan
UCCE	University of California Cooperative Extension
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Department of Agriculture, Forest Service
WLPZ	Watercourse and lake protection zone

Introduction

Monitoring the impacts of forestry related activities on water quality is an important issue for California. Aquatic species continue to be listed as threatened or impaired by state and federal agencies, such as the state listing of coho salmon in August 2002. The Regional Water Quality Control Boards are considering how to address a legislatively mandated expiration of waivers on January 1, 2003, for silvicultural activities under the Clean Water Act. The listing of numerous North Coast watersheds as impaired waterbodies under Section 303(d) of the Clean Water Act and the implementation of Total Maximum Daily Load (TMDL) requirements are significant issues to numerous landowners. Additionally, debate continues on the appropriate protection measures needed along small headwater streams for adequate water quality protection. Scientifically credible monitoring data is needed to help resolve these issues and to reach sound conclusions regarding the impacts of current timber operations on water quality.

The purpose of the Hillslope Monitoring Program is to determine if California's Forest Practice Rules are adequately protecting beneficial uses of water associated with commercial timber operations on nonfederal lands in California. In June 1999, the California State Board of Forestry and Fire Protection's Monitoring Study Group presented an interim report documenting preliminary findings from its Hillslope Monitoring Program (CSBOF 1999). Additional data collected over the past three years is now sufficient for the preparation of a second report on the project. Hillslope monitoring will continue in the future, with refined protocols for improved tests of individual practice effectiveness. Continued monitoring is also needed to evaluate changes in the California Forest Practice Rules, the issues raised above, and the changing expectations of resource agencies and California's citizens.

The Hillslope Monitoring Program is not the only approach used in California to determine impacts of timber operations to water quality. Other efforts to evaluate how well California's Forest Practice Rules are implemented and how effective they are in protecting water quality include: 1) extensive inspection, enforcement, and monitoring by California Department of Forestry and Fire Protection Forest Practice Inspectors, and 2) research conducted as part of detailed watershed studies, such as the Caspar Creek watershed study. Each approach has its advantages and disadvantages. The Hillslope Monitoring Program described in this report complements these efforts, and when combined with the results from other monitoring efforts, conclusions can be reached regarding Rule implementation and effectiveness (Ice et al. 2002).

Specific objectives of the Hillslope Monitoring Program are: 1) implementation monitoring to determine if the Forest Practice Rules (FPRs) related to water quality are properly implemented, and 2) effectiveness monitoring to determine if the FPRs affecting water quality are effective in meeting their intent when properly implemented. Both implementation and effectiveness monitoring are necessary to differentiate between water quality problems created by non-compliance with a FPR, versus problems with the practice itself. The goal of effectiveness monitoring is to provide information on where, when, and in what situations problems occur under proper implementation (Tuttle 1995). Determining which Rules have the poorest implementation and effectiveness and the highest frequency of violations both provides input to the BOF on needed Rule changes and identifies training needs for: (1) CDF's Forest Practice Inspectors; (2) Registered Professional Foresters (RPFs) submitting THPs; and (3) Licensed Timber Operators (LTOs).

Background Information

California's modern Forest Practice Act (FPA) was adopted in 1973, with full field implementation occurring in 1975, and many monitoring efforts have taken place over the past two decades to learn more about the implementation and effectiveness of California's Forest Practice Rules in protecting water quality. These monitoring efforts complement the California Department of Forestry and Fire Protection (CDF) Forest Practice compliance inspection program that has been in place for over 25 years.

Under the FPA, Timber Harvesting Plans (THPs) must be submitted to CDF and approved for commercial timber harvesting on all non-federal timberlands. THPs are reviewed for compliance with the FPA and the Forest Practice Rules adopted by the Board of Forestry and Fire Protection (BOF), as well as other state and federal regulations protecting watersheds and wildlife. CDF, along with the Department of Fish and Game, Regional Water Quality Control Boards, and the California Geological Survey, conducts Pre-Harvest Inspections (PHIs) of proposed harvest areas to determine if plans are in compliance with the Act and FPRs. During PHIs, additional mitigation measures beyond the standard rules are often recommended based upon site-specific conditions. This report focuses on water quality issues, but the added THP mitigation also relates to habitat protection, public safety, and numerous other public trust resources. CDF also conducts inspections during active timber operations and the post-harvest period when logging is completed to assess compliance with the Act, the FPRs, and the specific provisions of the THP.

The State Water Resources Control Board (SWRCB) certified the Forest Practice Rules and review process as Best Management Practices under Section 208 of the Federal Clean Water Act in 1984, with a condition that a monitoring and assessment program be implemented. Initially, a one-year qualitative assessment of forest practices was undertaken in 1986 by a team of four resource professionals (Johnson 1993) that audited 100 THPs distributed across the state and produced the final "208 Report" (CSWRCB 1987). The team found that the Rules generally were effective when properly implemented on terrain that was not overly sensitive, and that poor Rule implementation was the most common cause of observed water quality impacts. They recommended several changes to the FPRs based on their observations.

Additional water quality monitoring projects in the 1980's related to the Forest Practice Rules include the Critical Sites Erosion Study (CSES), conducted within watersheds throughout northern California, and the North Fork phase of the Caspar Creek watershed study, located near Fort Bragg. Objectives of the CSES project were to determine site characteristics on THPs that could be used to identify potential large erosion features, and to identify management factors which may have been responsible for erosion events. This project collected data during 1985 and 1986 on management and site factors associated with existing mass wasting events on a random sample of 314 THPs covering over 60,000 acres (Durgin et al. 1989; Lewis and Rice 1989, Rice and Lewis 1991). A brief summary of the Caspar Creek watershed study findings is included in the following section under Summary of Related Studies.

In 1988, the Board of Forestry, CDF, and the SWRCB entered into a Management Agency Agreement (MAA) that required the BOF to improve forest practice regulations for protection of water quality based on needs described in the “208 Report.” At this point, the SWRCB approved final certification of the FPRs as Best Management Practices. The U.S. EPA, however, withheld certification until the conditions of the MAA were satisfied, one of which was to develop a long-term monitoring program (LTMP).

In response to the MAA conditions, the BOF formed an interagency task force, later known as the Monitoring Study Group (MSG), in 1989 to develop this long-term monitoring program that could test the implementation and effectiveness of FPRs in protecting water quality. With public input, the MSG developed a LTMP with both implementation and effectiveness monitoring components, and conducted a pilot project to develop appropriate techniques for both hillslope and instream monitoring (CSBOF 1993). CDF has funded this monitoring program since 1990.

From 1989 to 1999, the MSG was an “ad hoc” committee which met periodically to: 1) develop the long-term monitoring program, and 2) provide guidance to CDF in implementing the program. The MSG was designated as an Advisory Committee to the Board of Forestry and Fire Protection in January 2000. The MSG continues to refine the long-term monitoring program testing the effectiveness of California’s Forest Practice Rules and provide oversight to CDF in implementing the program.

The primary goal of the MSG’s monitoring program has been to provide timely information on the implementation and effectiveness of forest practices related to water quality for use by forest managers, agencies, and the public. CDF and BOF chose to place more initial emphasis on hillslope monitoring for the Long-Term Monitoring Program because it can provide a more immediate, cost effective and direct feedback loop to resource managers on impacts from current timber operations when compared to instream monitoring (particularly channel monitoring which involves coarse sediment parameters) (Reid and Furniss 1999). As stated in Robben and Dent (2002), it is usually easier to identify a sediment source and quantify the volume of sediment it produced, when compared to measuring sediment in the watercourse and tracing it to the source.

The components of the Long-Term Monitoring Program are described in the MSG’s Strategic Plan (CSBOF 2000) adopted by the BOF in 2000. This program is robust—utilizing a combination of approaches to generate information on Forest Practice Rule implementation and effectiveness related to water quality. The major components of the program include: 1) continuation of the Hillslope Monitoring Program, 2) use of CDF Forest Practice Inspectors to collect hillslope monitoring data on a random sample of completed THPs as part of a Modified Completion Report (MCR), 3) development of scientifically credible monitoring plans for cooperative watershed monitoring projects in selected basins to provide instream monitoring data, and 4) development and/or funding of selected monitoring projects that can answer key questions about forest practice implementation and effectiveness.

To date, considerable information has been collected by projects conducted as part of each of these components of the Long-Term Monitoring Program. A summary of what has been learned so far as part of the Modified Completion Report monitoring process is included in the following section of this report. One cooperative instream monitoring project has been started in the Garcia River watershed. The first phase of the project provided a watershed assessment and instream monitoring plan (Euphrat et al. 1998). The second phase was implementation of the instream monitoring plan to document baseline habitat conditions, which will allow examination of long-term trends to determine if instream conditions are improving. A final report documenting baseline measurements made in 1998 and 1999 for parameters such as water temperature, canopy and shading, gravel composition and permeability, large wood loading, sediment source areas, fish surveys, channel cross sections, and thalweg profiles was produced in 2001 (Maahs and Barber 2001). In 2002/2003, smaller scale cooperative instream monitoring projects are planned in Mendocino County with Campbell Timberland Management/ Hawthorne Timber Company, and in the Sierra Nevada/Cascade province with Sierra Pacific Industries.

Additionally, numerous monitoring projects have been supported, or are currently being supported, by CDF that provide critical information related to monitoring techniques and/or answer key questions regarding forest practice implementation and effectiveness. Examples of these projects include:

- Testing Indices of Cold Water Fish Habitat—Knoop (1993)
- V-Star Tests in Varying Geology— Lisle (1993), Lisle and Hilton (1999)
- Erodible Watershed Index--McKittrick (1994)
- Evaluation of Road Stream Crossings (Flanagan et al. 1998)
- Sediment Storage and Transport in the South Fork Noyo River Watershed, Jackson Demonstration State Forest (Koehler et al. 2001)
- Sediment Composition as an Indicator of Stream Health (Dr. Mary Ann Madej, USGS, and Dr. Peggy Wilzbach, HSU; in progress)
- Central Sierra Nevada Sediment Study (Dr. Lee MacDonald, CSU; in progress)
- Caspar Creek Watershed Study—Ziemer 1998, Lewis et al. 2001 (Dr. Robert Ziemer, USFS-PSW (retired), Dr. Thomas Lisle, USFS-PSW, in progress)

Final reports for completed projects, as well as other earlier monitoring reports and papers, detailed information on the Modified Completion Report monitoring process, the MSG Strategic Plan, and agendas for upcoming MSG meetings are available online at: **http://www.fire.ca.gov/bof/board/msg_geninfo.html**

Over 100 papers and reports documenting findings from the Caspar Creek Watershed Study are available online at:
http://www.rsl.psw.fs.fed.us/projects/water/caspubs.html

Summary of Other Related Studies

Several recently completed and ongoing monitoring efforts are related to the hillslope monitoring work reported on in this document. Many of the findings in these studies are similar to and support results described in this Hillslope Monitoring Program report.

Colorado State University, Department of Earth Resources— Central Sierra Nevada Sediment Study. Dr. Lee MacDonald and Drew Coe, Colorado State University, Fort Collins, CO (MacDonald and Coe 2001; Coe and MacDonald 2001; Coe and MacDonald 2002)

The objective of this research is to quantify natural and anthropogenic hillslope erosion rates for use in a spatially-explicit cumulative watershed effects model. Study sites are on the Eldorado National Forest and Sierra Pacific Industries land in the Central Sierra Nevada. Approximately 150 sediment fences were installed in the summers of 1999 and 2000 to measure sediment production and sediment delivery to the stream network (Figure 1). Silt fences were installed in areas subjected to different management activities, including undisturbed sites, across three geologic types (volcanic, granitic, and metamorphic) and different elevation zones. Sediment production rates were measured for three winter periods (hydrologic years 2000 through 2002). The first winter was the wettest of the three years, while the second winter was drier and colder. The third winter was intermediate in terms of total precipitation and the duration of snow cover.

Data analysis is currently nearing completion, although several progress reports and presentations have described some of the initial key findings. The results have shown that native surface roads are the primary anthropogenic source of sediment. High rates of sediment production have also been documented for high severity wildfires and areas used for off-highway vehicles. Most harvest units and areas burned at low severity produced relatively little sediment. Overall, there was a large degree of variability between sites within a given management category as well as between years. For example, sediment production rates in the first year were 3 to 11 times higher than the sediment production rates for the second winter, and this is due in large part to the lower amounts of precipitation and more consistent snow cover.

Data from the first winter showed that, on average, native-surface roads generated approximately seven times as much sediment as harvest units and landings. These results led to a greater focus on sediment production from native surface roads. Data from the next two winters indicated that recently-graded native surface roads produced twice as much sediment as comparable segments that had not been graded. Road surface area, slope, annual precipitation, elevation, and grading (i.e., recently graded vs. ungraded) were the primary controls on road sediment production. The product of road surface area and road gradient was the single best predictor of road surface erosion, and this explained from 40 to 65% of the variability within a given year. Rocked roads produced only 2-4% as much sediment as comparable native surface roads. Relative to the other factors, soil type was not an important control on sediment production from the native surface roads. However, the limited data suggest that erosion rates from harvest units on granitic soils can be as much as an order of magnitude larger than the erosion rates from harvest units on volcanic soils.

A survey of 285 road segments as defined by specific drainage outlets (e.g., waterbar, rolling dip, or culvert) indicated that approximately 18% of the segments (20% of the total surveyed length) had gullies or sediment plumes that reached to within 10 m (33 ft) of a stream channel. Road crossings accounted for 58% of the road segments that were connected to the stream network.

Overall, the highest sediment production rates were often associated with insloped road segments located downslope of areas with shallow, impermeable bedrock. Because the product of area and slope was a dominant control on road segment sediment production, the older roads with inadequate drainage produced much more sediment per unit area than roads that followed current drainage specifications. Hence the best means to reduce erosion rates from native surface roads is to alter the road surface by rocking, decreasing the product of area and slope by improving and maintaining road drainage, and avoiding areas with shallow bedrock that increase sideslope drainage and increase ditch runoff. Areas with shallow bedrock also appear to facilitate the generation of extended gullies that can link roads to the stream network. These segments, together with road crossings, account for nearly all of the road-derived sediment that is being delivered to the stream network.

Figure 1. Example of one of 147 sediment fences installed to measure sediment production rates in the central Sierra Nevada Mountains (photo by Drew Coe used with permission).

US Forest Service—Pacific Southwest Region—Best Management Practice Evaluation Program. Brian Staab, USFS, Vallejo, CA (Staab 2002)

The U.S. Forest Service's (USFS) Best Management Practices (BMP) Evaluation Program in California is focused on hillslope monitoring of BMP implementation and effectiveness. Preliminary results indicate that USFS silvicultural BMPs are generally implemented and effective. Statewide, average implementation and effectiveness rates from 1992-2001 were both approximately 87% (n=2900 random evaluations). Yearly rates of BMP implementation and effectiveness ranged from 83% to 91% and 78% to 92%, respectively. Effectiveness rates were above 85% every year except 1997. Implementation and effectiveness rates, respectively, for specific silvicultural BMPs were as follows: streamside management zones: 82%/79% (n=248); skid trails: 84%/91% (n=276); suspended yarding 97%/90% (n=87); landings: 90%/95% (n=373); timber sale administration (n=62): 95%/98%; special erosion control and revegetation: 84%/96% (n=57); meadow protection: 93%/95% (n=121); road surface, drainage and slope protection: 87%/84% (n=238); stream crossings: 86%/80% (n=259); control of sidecast: 81%/89% (n=185); servicing and refueling: 95%/97% (n=38); in-channel construction practices: 92%/61% (n=115); temporary roads: 91%/88% (n=120); rip rap composition: 91%/82% (n=22); snow removal: 85%/87% (n=163); pioneer road construction: 96%/56% (n=25); management of roads during wet periods: 92%/85% (n=61); prescribed fire: 77%/95% (n=231); vegetation manipulation: 89%/96% (n=93); and revegetation of surface disturbed areas: 84%/76% (n=85).

Oregon Department of Forestry—Best Management Practices Compliance Monitoring Project: Final Report. Joshua Robben and Liz Dent, ODF, Salem, OR (Robben and Dent 2002)

The ODF Forest Practice Monitoring Program implemented the BMP Compliance Monitoring Project to evaluate compliance with BMPs on non-federal forestlands in Oregon. This was a three year statewide project, with the first year (1998) being a pilot study to develop and test protocols. A total of 189 harvest operations were randomly selected, using criteria that favored selection of units with fish-bearing waters. At the selected units, harvesting practices, roads, skid trails, stream crossings, riparian management areas, wetlands, etc. were evaluated for compliance with 150 Forest Practice Rules designed to protect water quality and fish habitat. Monitoring was completed by a former Forest Practices Forester who rated individual BMP applications as compliant or noncompliant. The type and magnitude of resulting riparian and channel impacts were recorded for noncompliant practices.

A total of approximately 13,500 BMP applications were evaluated and the overall compliance rate was 96.3%. Specific practices that were found to have the poorest compliance (less than 96% compliance and five or more noncompliance practices) are: slash piling within waters of the state (89.6%), removal of petroleum-related waste from the unit (82.0%), stream crossing fill stability (84.3%), road surface drainage design (86.5%), road surface drainage maintenance (94.2%), restrictions on felling of trees into small streams (83.1%), skid trails not located within 35 feet of Type F streams (91.5%), skid trails located so that stream water will not flow onto the skid trail (92.5%), removal of temporary crossings (47.8%), protection of other wetlands (69.8%), prior approval requirements (90.4%), and written plan requirements (77.1%).

Approximately 500 noncompliant practices were recorded and 185 of these were administrative requirements not directly affecting water quality. About 65% of the noncompliant practices either had impacted water quality or had the potential to impact riparian and channel conditions in the future. The greatest source areas of sediment delivery were from 36 noncompliant road construction and maintenance practices. To improve BMP compliance, the results of this monitoring work are being presented to landowner groups, operator workshops, and Oregon Department of Forestry conferences. Additionally, the results are being used to clarify guidance language, develop additional implementation tools, and guide future monitoring work.

California Department of Forestry and Fire Protection—Modified Completion Report Monitoring Progress Report. Clay Brandow, CDF, Sacramento, CA (Brandow 2002)

As part of the CDF's Forest Practice Program, the Department's Forest Practice Inspectors collect hillslope monitoring data for areas of the landscape that have been found in previous monitoring work to be either particularly sensitive to disturbance or having significant impacts to water quality. For each THP evaluated, a randomly selected road segment (1000 feet), a randomly selected WLPZ segment (200 feet), and two randomly located watercourse crossings are rated for FPR implementation at the time logging is completed. Effectiveness of erosion control facilities and crossing design/construction are rated a second time for the same road segment and crossings during an Erosion Control Maintenance inspection after one to three overwintering periods. Rating implementation immediately following logging and effectiveness after stressing winter storms follows the guidelines suggested by Lewis and Baldwin (1997) in a statistical review of the Hillslope Monitoring Program. Sample size is a random selection of 12.5% of THPs undergoing Work Completion Report field inspections. As of September 2002, 132 THPs have been sampled, with 101 having a Class I or II WLPZ. Class I WLPZ total canopy has averaged 83% in the Coast District and 68% in the inland (Northern and Southern) districts. Class II total canopy has been similar, with 83% and 69% in the Coast and inland districts, respectively. For the road segments to date, 15% of evaluated stretches have had at least one departure from the FPRs. Most of the departures have related to waterbreak spacing, waterbreak discharge into cover, and waterbreak construction. Additionally, 145 crossings have been sampled, and FPR departure rates have been found to be low (contrary to Hillslope Monitoring Program results). This may be due to: 1) fewer overwintering periods; 2) differences in monitoring forms, rating categories, and reviewer opinions; and 3) requirement for major problems to be fixed prior to plan completion report approval.

US Forest Service—Pacific Southwest Research Station—Caspar Creek Watershed Study. Dr. Robert Ziemer, Chief Research Hydrologist (retired), Redwood Sciences Laboratory, Arcata, CA; Dr. Thomas Lisle, Research Hydrologist, Redwood Sciences Laboratory, Arcata, CA. (Ziemer 1998, Lewis 1998, Cafferata and Spittler 1998, Lewis et al. 2001, Lewis 2002)

Results from the Caspar Creek watershed study located near Fort Bragg, California show that improved forestry practices after 1974 have significantly reduced sediment yields in the past two decades. Selection logging conducted prior to the implementation of the modern Rules in the South Fork of Caspar Creek produced from 2.4 to 3.7 times more suspended sediment compared to that produced by clearcutting in the North Fork under the modern Rules. Suspended sediment monitoring in the North Fork of Caspar Creek following clearcut harvesting of almost half the watershed in three years under the modern Forest Practice Rules showed that annual sediment loads increased 123-269% in the tributaries. At main-stem stations, however, increased loads were detected only in small storms and there was little effect on annual sediment loads. Most of the suspended sediment generated at the North Fork weir resulted from one large landslide that occurred in January 1995.

The overall conclusion from the Caspar Creek watershed study is that logging operations conducted under the modern Forest Practice Rules produce much less sediment than logging in the early 1970's prior to the implementation of these Rules. Unit area sediment loads from four storm events in hydrologic year 2001 show that sediment yields are higher in several South Fork tributary watersheds, without disturbance for almost 30 years, than was found in clearcut tributary basins in the North Fork that were logged approximately 10 years ago. Much of this difference is attributed to poor design, construction, and maintenance of pre-modern Forest Practice Rule roads, landings, and skid trails.

Road rehabilitation work was conducted during the summer of 1998 on three miles of old road constructed along the South Fork in 1967. A total of 33 watercourse crossings were abandoned, removing a total of approximately 28,500 cubic yards of fill material. Surveys of the abandoned crossings have shown that downcutting following large winter storm events, including a 40-year recurrence interval event the first winter following excavation, has resulted in 854 cubic yards of sediment, or three percent of the total amount of sediment removed, being washed downstream. Most of this material came from three crossings. Approximately 500 cubic yards were lost from one abandoned crossing on the mainstem of the South Fork, primarily from upstream residual deposits of sediment above an old splash dam built in the 1860s. The other two problem crossings each lost 50 to 70 cubic yards of sediment due to downcutting at the crossing site. Little additional downcutting has occurred after the first winter following excavation (W. Baxter, CDF—Jackson Demonstration State Forest, Fort Bragg, CA, personal communication).

Study Design

Overview

The Hillslope Monitoring Program began in 1993 with a pilot project designed to develop and test monitoring procedures. Dr. Andrea Tuttle and CDF began the process by modifying previously developed U.S.D.A. Forest Service hillslope monitoring forms developed for the Pacific Southwest Region (USFS 1992). Modifications were made to allow detailed information to be recorded for locations within Timber Harvesting Plans (THPs) that were felt to present the greatest risk to water quality--roads, skid trails, landings, watercourse crossings and watercourse and lake protection zones (Tuttle 1995). The forms developed for the U.S. Forest Service monitoring program did not adequately identify the specific requirements of the Forest Practice Rules. As a result, these initial forms were either substantially modified (i.e., watercourse crossings and landings) or completely re-written (i.e., transect evaluations were developed for roads, skid trails, and watercourse and lake protection zones). Dr. Tuttle and CDF prepared new forms for practices that are unique in the FPRs, and developed methods for measuring and identifying features related to Rule implementation and effectiveness. Harvest units were not included because few of the Rules apply to these areas and previous studies had shown that most of the erosion features were associated with the more disturbed sites (Durgin et al. 1989).

As part of the hillslope component of the Pilot Monitoring Project, Monitoring Study Group members identified all of the separate Forest Practice Rule requirements that could be related to protection of water quality. This resulted in a list of over 1300 separate items, including plan development, the review process, and field application requirements. This list was then pared down to 191 Rule requirements that are implemented during the conduct of a Timber Harvesting Plan and can be evaluated by subsequent field review. Many of the Rule sections with multiple requirements were broken down into their separate components for field evaluations.[1] FPRs related to cumulative watershed effects and the THP review process were not included because they could not be evaluated using an on-the-ground inspection of the THP area. The overall goal of the Hillslope Monitoring Program has been to collect data that can, over time, provide information on: 1) how well the Rules are being implemented in the field, and 2) where, when, and to what degree problems occur—and don't occur—under proper implementation (Tuttle 1995).

The California Division of Mines and Geology (now known as the California Geological Survey) assisted with the hillslope pilot program and provided detailed geomorphic mapping for two of the watersheds used for the pilot work (Spittler 1995). The California Department of Fish and Game completed the pilot project work for the instream monitoring component of the program (Rae 1995). The Pilot Monitoring Program was completed during 1993 and 1994, and final reports were prepared in 1995. Pilot

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[1] The Forest Practice Rules referred to in this report, including all the tables, are based on the Rules in effect in 1994. Changes to the FPRs since that time have affected the letters and numbers assigned to some individual Rules, but the listed Rules remain in effect in the same Rule Section.

Monitoring Program Manager Gaylon Lee of the SWRCB prepared a summary document that included a detailed description of what had been learned about hillslope monitoring and made recommendations for the long-term program (Lee 1997).

Site Selection

Data collection for the BOF/CDF Hillslope Monitoring Program began in 1996 with a stratified random sample of 25 THPs in both Humboldt and Mendocino Counties to collect information from watersheds with coho salmon habitat, due to the proposed federal listing of that species.[2] Contracts were developed with the Resource Conservation Districts (RCDs) in each county, and the RCDs hired Registered Professional Foresters (RPFs) to collect the required field data on THPs that had over-wintered for a period of one to four years. Natural Resources Management Corporation (NRM) was the contractor hired by the Humboldt County RCD, while R.J. Poff and Associates was hired by the Mendocino County RCD. Stratified random sampling was utilized to select the THPs for work completed in 1996. Using erodibility ratings developed as part of a study completed by the California Division of Mines and Geology (now the California Geological Survey) (McKittrick 1994), approximately 50 percent of the THPs evaluated were included in the areas designated as having high overall erosion hazard, 35 percent were included in the moderate category, and 15 percent were included in the low erosion hazard rating.[3]

From 1997 through 2001, field data was collected from a statewide random sample of 50 THPs each year. These THPs were not stratified based on the CGS erodible watershed categories utilized in 1996. While only a fraction of all completed THPs were evaluated, the random sample design ensured that the results were representative of all the THPs harvested during the same period. Beginning in 2001, Nonindustrial Timberland Management Plan (NTMP) Notices of Timber Operations (NTOs) (or NTMP projects) were included as part of the sample because of the growing number of NTMPs statewide, and a lack of information regarding rule implementation and effectiveness on these projects. NTMPs are long-term management plans for small nonindustrial timberland owners. When a portion of the area covered by the NTMP is to be harvested, an NTO is submitted to CDF for review and is valid for one year following approval.

CDF's RBASE Forest Practice Database was queried from 1996 through 1998 in Santa Rosa, Redding, and Fresno to produce a combined list of potential THPs meeting the completion and acceptance dates (approximately 2,500 THPs were in the population).

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[2] Coho salmon were listed by the NMFS as threatened for the Southern Oregon/Northern California Coasts Coho ESU in 1997.

[3] This project rated large (e.g., 50,000 acre) watersheds on their inherent erodibility, excluding land use impacts. Variables input into a GIS model included precipitation, slope, and geology. A low, moderate or high rating was assigned to each factor. Numbers were summed to create an ordinal display of relative susceptibility of watersheds to erosion.

Beginning in 1999, CDF's new Oracle Forest Practice Database system was queried in Sacramento to generate the list of potential THPs and, in 2001, NTMP NTOs, with appropriate completion and acceptance dates.

These queries produced a preliminary, randomized list of THPs and NTMP NTOs to evaluate. Individual THP and NTMP files were then reviewed at CDF's regional offices in Santa Rosa, Redding, and Fresno to determine whether the individual plans met the criteria for when the logging was completed, the length and types of watercourses present, yarding system(s) utilized, plan or project size, and wildland classification described below. THPs eliminated from the preliminary list were replaced with the next THP meeting the above criteria, keeping the original percentages for each CDF Forest Practice District (i.e., Coast, Northern and Southern) established in the random sort.[4] The statewide sample, therefore, is very similar to the distribution of THPs CDF receives at each of its three Forest Practice District offices.

Specifically, THPs and NTMP NTOs were included in the study if they met the following criteria:

1. The THP had been filed and completed under the Forest Practice Rules adopted by the BOF after October 1991 (when the most recent WLPZ rules were implemented prior to adoption of the Threatened and Impaired Watersheds Rule Package in July 2000).

2. The THP was not accepted by CDF after the adoption of the July 2000 Threatened and Impaired Watersheds Rule Package.

3. The plans had been through at least one**,** but not more than four winters, since logging was completed. To ensure that plans met this requirement, the CDF Work Completion Report for the entire THP must have been signed by a CDF Forest Practice Inspector, and the date used to determine the one to four over-wintering periods was the date supplied by the RPF that indicated when all the logging was completed on the THP. This length of over-wintering provided the opportunity for erosion control measures to be tested by wet-weather prior to the field evaluation of effectiveness.

4. The THP or NTMP NTO was primarily composed of wildlands (e.g., it was not a campground or golf course). Also, the THP or NTMP NTO could not be a road-right-of-way-only plan.

5. The THP or NTMP NTO was not entirely helicopter logged and had significant components of either ground based tractor logging and/or cable yarding systems.

[4] If this were not done, a much higher percentage of THPs would have been selected from the Coast Forest Practice District, since many more of these plans have the required watercourse length.

6. The THP or NTMP NTO had at least 500 continuous feet of a Class I or II watercourse present, or the project boundary was a distance from the Class I or II watercourse that would correspond to what the Forest Practice Rules would prescribe for a WLPZ for that watercourse type and slope.

7. The THP was at least 5 acres in size.

8. The THP was not previously sampled.

Permission for THP access was first requested in a letter written by CDF and then with follow-up telephone calls made by the contractor for those plans where a response was not received. CDF stressed that there was no possibility of legal actions as a consequence of the field inspection, since no citations or violations could be issued by our contractor. Where permission was not granted, the next THP on the list was used. Permission was received from large industrial owners for all but one THP. In contrast, more than 50 percent of the selected THPs on small, nonindustrial timberlands were excluded from the study because of either an inability to locate the landowner, sale of the parcel, or denial of access. This resulted in the study being weighted toward the industrial timberlands.

Starting in 2000, to prevent additional bias in the sample towards large industrial forest landowners, large forest landowner THPs that were rejected due to a lack of access were replaced with other large landowner plans, and small landowner plans were replaced with other small landowner THPs. Large landowners were arbitrarily defined as having combined ownership in California of at least 6,000 acres based on a list of landowners and their ownership size developed by CDF Forest Practice Program staff. This practice was largely successful, but a few large industrial plans were still needed at the last moment when small non-industrial landowners changed their mind about access.

When permission for access was received for 50 THPs and NTMP NTOs, a final list of projects was developed and copies of the THPs and NTMPs were made by the CDF Regional Offices for the contractor. The contractor was supplied with copies of the Pre-Harvest Inspection reports, Amendments, Notices of Violations, and Final Work Completion Reports (including maps). Alternate THPs were supplied for each Forest Practice District in 1999, 2000, and 2001 in addition to the 50 THPs and NTMP NTOs. This was necessary to provide alternate plans for situations where field inspection revealed that the THP would not be acceptable for monitoring (e.g., all the roads had their drainage structures removed for more recent logging activities).

Data Collection

The monitoring work was conducted by independent contractors who acted as third party auditors (Figure 2). CDF developed the bid package, advertised the bid package, accepted bids from qualified contractors, and hired the qualified contractor with the lowest bid for each year from 1997 through 2001. To qualify, bidders must have met the following requirements:

1. The Contractor must have been a Registered Professional Forester (RPF) in the state of California. The Contractor could employ assistants who were not Registered Professional Foresters who worked under the supervision of the RPF and the on-site team conducting each THP or NTMP NTO must have included at least one RPF and one earth scientist (note that one person meeting both requirements could fill this role).

2. The Contractor must have had experience in the development, implementation, and evaluation of THPs on private timberlands within the state of California.

3. The Contractor must have had a working knowledge of the California Forest Practice Rules and experience with tractor and cable logging operations.

4. The Contractor's team must have had experience evaluating hillslope erosion problems, and must have had at least one member who was an earth sciences specialist with soil science or geology expertise and who had experience working with forested environments. To meet this criteria, one of the team members must have been either a **Certified Professional Soil Scientist** (CPSS) (as designated by the American Registry of Certified Professionals in Agronomy, Crops, and Soils) or a **California Registered Geologist** (RG) (as designated by the Board for Registration of Geologists and Geophysicists).[5]

5. The Contractor must have had an extensive background in monitoring, including experience with on-site monitoring to evaluate the impacts of timber operations on water quality.

The contractor for each of these contracts from 1997 to 2001 was R.J. Poff and Associates. Mr. Roger Poff was the U.S.D.A. Forest Service North Sierra Zone Soil Scientist and was stationed on the Tahoe National Forest from 1980 to 1993. He is both a Certified Professional Soil Scientist and a Registered Professional Forester (RPF) in California. Assisting Mr. Poff were Mr. Cliff Kennedy, an RPF in California, and Mr. Joe Hiss, the principles of High Country Forestry.[6]

Field work was conducted during the spring, summer, and fall months. During the site inspections, data was recorded by the contractor on paper field forms supplied by CDF. Detailed information was collected on: 1) randomly located road, skid trail, and watercourse protection zone segments; randomly located landings and watercourse crossings; 2) large erosion events (e.g., mass wasting features) where they were encountered, and 3) non-standard practices and additional mitigation measures when they were utilized at the randomly sampled locations. A set of forms was provided for each of these subject areas, with sub-sections for site information, non-standard practices and additional mitigation measures, rule implementation, and rule

[5] From 1997 to 1999, the bid package specified that the one of the members of the field team must be either a RG, CPSS, or a Certified Professional Erosion and Sediment Control Specialist (CPESC).

[6] Mr. Chris Hipkin, RPF, assisted R.J. Poff and Associates in 1996 in Mendocino County.

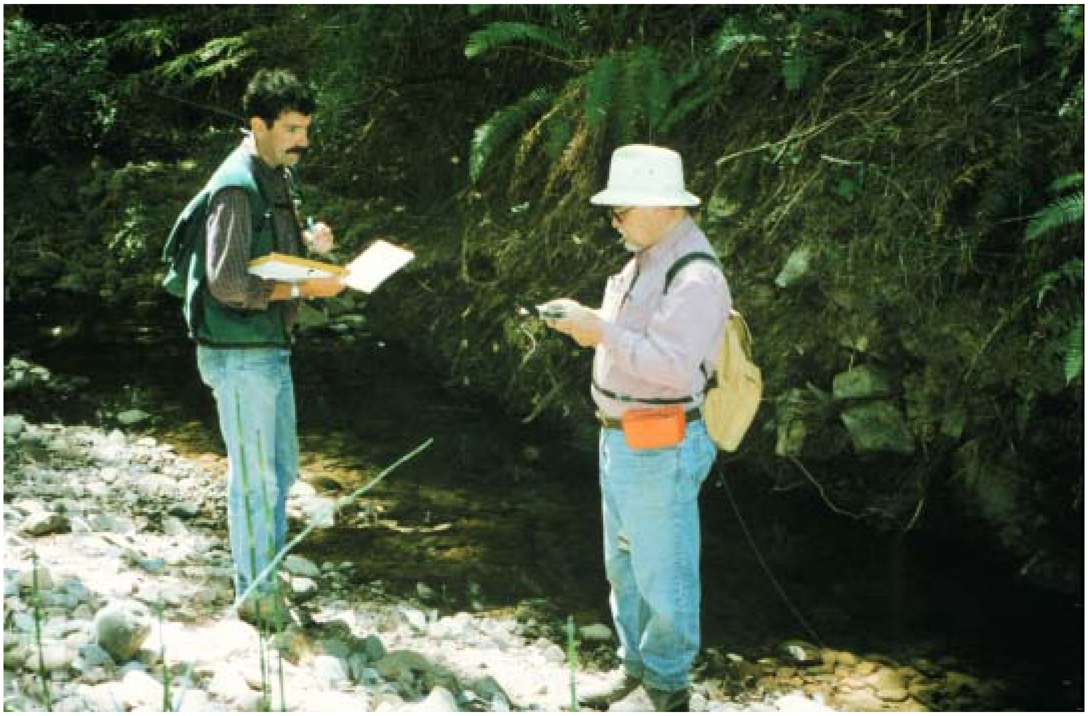

Figure 2. Field data was collected by highly qualified independent contractors who acted as third party auditors. Cliff Kennedy and Roger Poff are shown collecting field data in Mendocino County.

effectiveness. Direct observation of fine sediment delivery to stream channels during storm events was not attempted with this dry season program.

A Hillslope Monitoring Program database was developed in Microsoft Access for Windows (Microsoft Office 97) and runs on a personal computer. It is a relational database, approximately 30 megabytes in size without data. The data collected in 1996 was entered into the database by CDF. From 1997 to 2001, data was entered into the database by CDF's contractor. A preliminary set of queries were developed for the interim report prepared in 1999 (CSBOF 1999). These queries and additional, new queries were utilized for the current report.

Quality Assurance/Quality Control (QA/QC)

Quality assurance consists of actions to ensure quality data collection and analysis, while quality control is associated with actions to maintain data collection and analysis quality consistent with study goals through checks of accuracy and precision. The quality assurance program was composed of three components: 1) minimum qualifications for the contractor (see above), 2) a detailed training program, and 3) protocols provided in a field instruction package. New contractors were trained in the field by CDF Forest Practice personnel who developed the field sampling procedures and a detailed set of instructions on the Hillslope Monitoring Program procedures was provided.

The quality control program was composed of the following components: 1) self-evaluation, 2) CDF review, and 3) independent review. Under self-evaluation, it was stressed that the contractor ensure that the forms were completed satisfactorily and that the features were mapped prior to leaving the field site. CDF field inspections were "front-loaded", meaning that more field inspections were completed early on in the program compared to later years. CDF remeasured selected transects for canopy measurements in made in 1996 and found that the canopy measurements reported by the contractors were approximately seven percent higher than the internal estimate. The CDF average for three transects in Humboldt County and three transects in Mendocino County was 77.4 percent (measured with a spherical densiometer). The contractor's measurement for these transects was 84.8 percent.

For independent review, a random sample of 10 THPs were chosen in 1997 for quality control work. Dr. Stephen Daus and Mr. Michael Parenti were hired by CDF to complete the field work for these THPs a second time to test the repeatability of the process. Three plans were located in the Coast Forest Practice District, three in the Northern District, and four in the Southern District. Eighteen WLPZ transects were evaluated (14 Class II watercourses and four Class I watercourses). The average canopy cover measured with a spherical densiometer by the Daus/Parenti team for the WLPZ transects was 70.7 percent. The corresponding average canopy measurement for the same 10 THPs by the R.J. Poff and Associates team was 64.4 percent. A paired T Test revealed that these means of these two groups are significantly different at alpha <0.05.

Site Characteristics

Of the 300 plans evaluated, 295 were THPs and five were NTMP NTOs. Most of the THPs in the sample were accepted by CDF in the early to mid-1990's and the harvesting was completed by the mid to late 1990's (Figure 3). None of the THPs evaluated were approved under the new July 2000 Threatened and Impaired Watersheds Rule Package.

The THPs and NTMP NTOs sampled from 1996 through 2001 are displayed by Forest Practice District in Table 1. About 60 percent of the plans were from the Coast Forest Practice District. The distribution of large and small landowners is displayed in Table 2, and approximately 60 percent were on timberlands owned by large landowners. Figure 4 shows the general location of the projects which were monitored. Table 3 displays the distribution of THPs and NTMP NTOs by county. Slightly more than half the plans were located in Humboldt and Mendocino Counties. The average size of the THPs classified as being filed by large landowners was 441 acres, while the average size of the THP filed by small landowners was 169 acres. Considering both categories, the overall average size was 341 acres. In total, the 300 projects covered 102,260 acres.

Table 1. Distribution of THPs and NTMP NTOs by Forest Practice District.

Forest Practice District	THPs/NTMP NTOs	Percent
Coast	183	61
Northern	78	26
Southern	39	13

Table 2. Distribution of THPs and NTMP NTOs by landowner category.

Landowner Category	Number of THPs/ NTMP NTOs	Percent of THPs/ NTMP NTOs
Large landowner	189	63
Small landowner	111	37

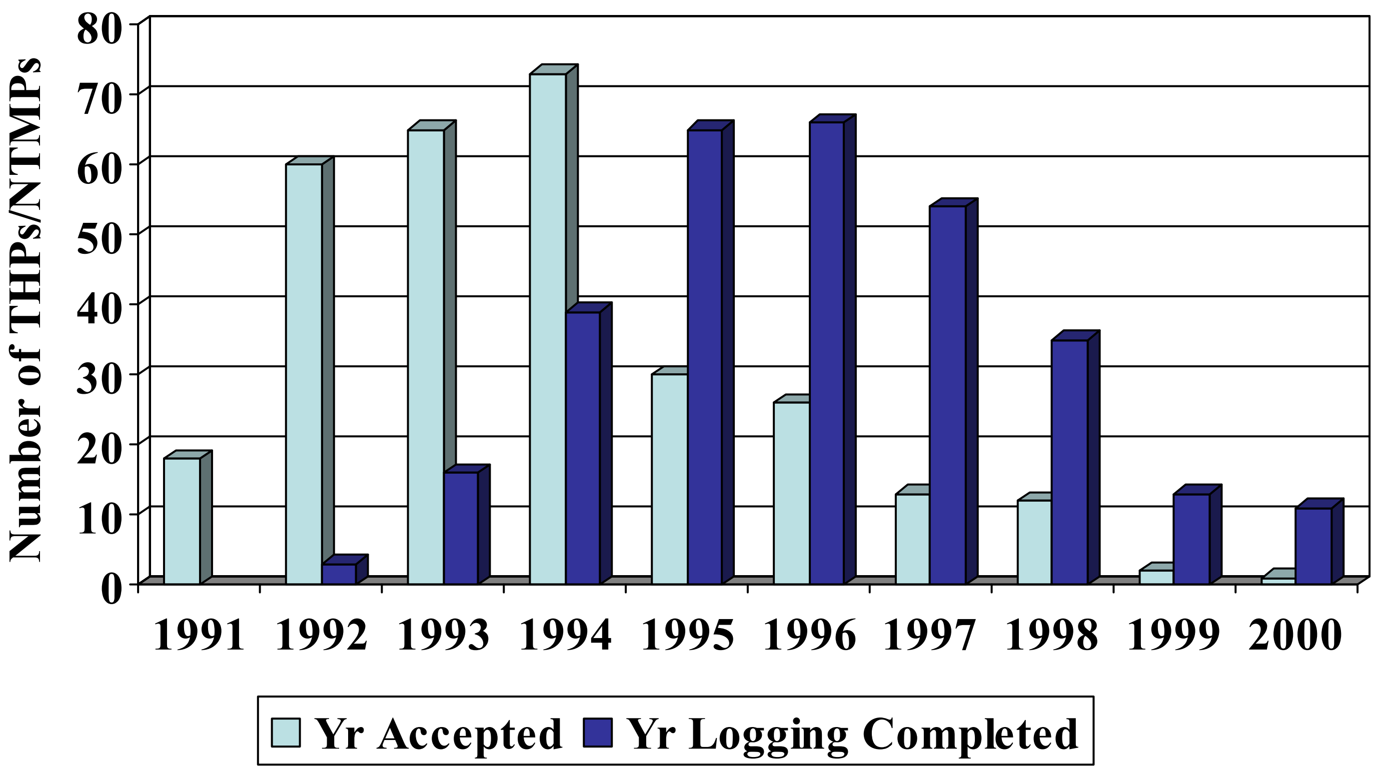

Figure 3. Distribution of when THPs and NTMP NTOs were accepted by CDF and when the logging was completed.

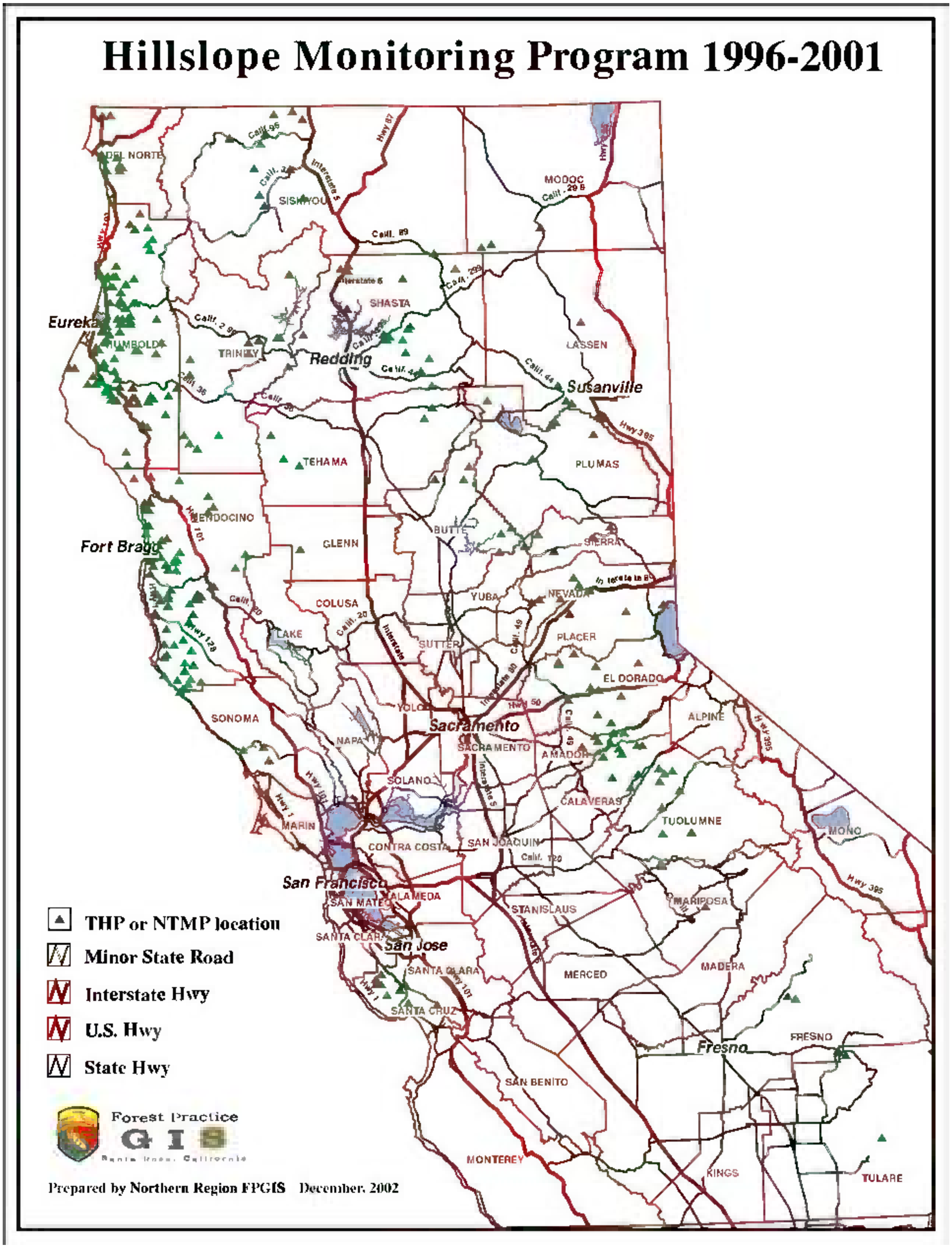

Figure 4. General location of THPs and NTMPs monitored from 1996 through 2001.

Table 3. Distribution of THPs and NTMP NTOs monitored from 1996 through 2001 by county.

County	North Coast THPs: 1996	Statewide THPs: 1997- 2001	Statewide NTMPs: 2001	Total Number of Projects
Coast Forest Practice District				
Del Norte		11		11
Humboldt	25	52	4	81
Mendocino	25	48	1	74
Santa Clara		2		2
Santa Cruz		7		7
Sonoma		4		4
Trinity		4		4
District Total	50	128	5	183
Northern Forest Practice District				
Butte		6		6
Glenn		1		1
Lassen		7		7
Modoc		3		3
Nevada		5		5
Placer		4		4
Plumas		4		4
Shasta		18		18
Sierra		3		3
Siskiyou		12		12
Tehama		5		5
Trinity		9		9
Yuba		1		1
District Total	0	78	0	78
Southern Forest Practice District				
Amador		6		6
Calaveras		8		8
El Dorado		10		10
Fresno		3		3
Mariposa		2		2
Tulare		2		2
Tuolumne		8		8
District Total	0	39	0	39
Totals	**50**	**245**	**5**	**300**

Methods

GENERAL INFORMATION

Five sample features were evaluated within each THP or NTMP NTO: roads, skid trails, landings, watercourse crossings, watercourse protection zones (i.e., WLPZs, ELZs, and EEZs). Two samples of each of these features were evaluated within each selected THP or NTMP NTO if possible. Large erosion events were inventoried where they were encountered on the THP or NTMP project. Additionally, non-standard practices and additional mitigation measures were evaluated when they applied to randomly located sample features.

Conducting the evaluations involved both office and field activity. Office work needed to prepare for the field evaluations included:

- Determining the plan location and access routes.

- Reading the THP or NTMP/NTMP NTO to identify and become familiar with Review Team requirements, alternatives, in-lieu practices, additional mitigations, and addenda in the approved plan.

The following items were completed either in the office or in the field:

- Filling out "Site Information" sheets for each sample site with information that could be obtained from the THP or NTMP NTO document.

- Laying out the road transect grid and WLPZ transect grid for selection of sample transects, as described under “Site Selection” below.

SITE SELECTION

Selection of specific sample areas began with marking approximate 500 foot road segments on all roads on the THP or NTMP NTO map. Each of these segments was assigned a number. A random number table or generator was then used to identify one of the segments. From this point, a coin was flipped to determine direction of travel along the road until a landing was encountered. This randomly selected landing was used for the landing sample. Where more than one road entered or exited the landing, coin flips were used to identify a road transect that began where the selected road left the landing. Coin flips were also used to determine the direction of travel to the first available skid trail transect. Watercourse crossing sites were selected as either the first crossing encountered during the road transect or, if no crossing was encountered, the first crossing along a road selected by a coin flip. Finally, the point on a Class I or Class II watercourse closest to the landing was used as the starting point for the WLPZ transect, and direction of travel along the WLPZ was determined by a coin flip. Either

GPS readings or topographic maps were used to record site locations with UTM coordinates.

FIELD ACTIVITIES COMMON TO ALL SAMPLE AREAS

The first step in the field work was to finish filling out Site Information sheets. This was followed by an effectiveness evaluation of pertinent features that presented an erosion or water-quality problem to permit calculation of the relative proportion of problem to non-problem areas.

Sample area field evaluations were designed to provide a database "sketch" of the sites and transects that were inspected. The resulting detailed information was used to estimate the proportion of Rule or water quality problems in the whole population of similar features. This also allowed evaluation of Forest Practice Rule implementation and effectiveness for protection of water quality and identification of problems requiring revisions or additions to the Forest Practice Rules.

At "problem" sites (such as cut bank failures, gullies, excessive grades, and Rule violations), the problem type, erosion, and sediment delivery codes were recorded and a Rule implementation evaluation was conducted. Any rills, gullies, mass failures, or sloughing features that were encountered as part of the transect and site inspections were followed to determine whether sediment from these erosional features reached a watercourse protection zone or stream channel.[7] The presence of rills, gullies or deposited sediment at the edge of the high flow channel was sufficient to class the sediment as having entered that portion of the stream.

After the field review had been completed, an evaluation of all the Rules was conducted based upon the <u>overall</u> frequency of problem sites and Rule violations found along the transect as a whole. Implementation of the Forest Practice Rules applicable to a given subject area was rated as either exceeding the requirements of the Forest Practice Rules, meeting the requirements, minor departure from requirements, major departure from requirements, not applicable, could not determine (evidence is masked), or could not evaluate (with description of why).

Major departures were assigned when there was a substantial departure from Rule requirements (e.g., no or few waterbars installed for entire transect), or where sediment was delivered to a watercourse. Minor departures were assigned for slight Rule departures (e.g., WLPZ width slightly less than that specified by the Rule).[8]

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[7] Rills, gullies, mass failures, and cutbank/sidecast sloughing are defined in the glossary.

[8] Minor and major departures from Forest Practice Rule have similar impact to water quality for watercourse crossings since sediment is assumed to enter the watercourse for both categories.

ROAD AND SKID TRAIL TRANSECT METHODS

Transects

The location of road and skid trail transects on the THP or NTMP NTO were determined using procedures described under Site Selection. Roads or skid trails that were not used as part of the THP or NTMP project being evaluated were not included. The starting point for the transect was the point at which the road or skid trail narrowed to its "normal width" and was outside of the influence of operations on the landing. Where a road forked, the transect followed the road that was of the same general type of construction and level of use. Where a skid trail forked, the branch that continued in the same basic direction (up-hill or down-hill) as the transect to that point was followed. If there were no clear differences, a coin flip was used to determine direction. The direction that was chosen was described in the comments section of the data form to provide a record for follow-up inspections or re-measurement, if required.

At the start of a transect, a measurement string was tied to a secure object, the string box counter was set to zero, and the location of the starting point was described in the comments for future reference. The road or skid trail was walked in the pre-determined transect direction for a distance of 1000 feet or to the end, whichever occurred first.[9]

If the total road distance was less than 800 feet, another transect on a different road segment was started from the landing without resetting the string box counter, and measurements were continued to obtain a total transect length of 1000 feet.

The minimum skid trail transect length was 500 feet. If needed, this distance could be made up of several segments. Skid trails were randomly selected from those entering the landing, where possible. If a skid trail was not available at this location, the nearest trail that brought logs to the measured road segment was used. Skid trail transects were no shorter than the length of trail requiring two waterbars. If the total skid trail distance was less than 300 feet, the transect was continued from the most recently passed trail intersection. Where there was no intersection, the transect was continued from the landing without resetting the string box counter, and the transect was continued in this fashion up to a maximum distance of 1000 feet. If there was less than 500 feet of skid trail, the available trail length was sampled and an explanatory comment was included. If there were no skid trials (i.e., the plan was entirely cable or cable/helicopter yarded), this was noted at the start of one of the skid trail forms.

Data Recording

The general procedure for linear transects was to record the starting and ending distance to each feature as it was encountered. On roads, for example, the beginning and ending point of all features (e.g., inside ditches, cut banks, location of waterbreaks,

[9] Note that main-line logging roads were not sampled if drainage structures had been removed to facilitate log hauling from more recent timber operations. This type of road (i.e., native surfaced primary road with waterbars) was probably under sampled as a result of these more recent operations.

cross drains, etc.) were recorded, regardless of whether or not they presented a water quality problem. Consecutive numbers were assigned to each feature, which, in combination with the THP and transect numbers, became a unique database identifier for that feature. Then codes were entered to indicate the type of feature and any associated drainage problems, erosion source area, erosion causes, and sediment production, plus information about road or trail gradient, sideslope steepness, and dimensions of erosion features. A feature date code was included for all erosion features, features with drainage problems, and other features related to Rule requirements to indicate if the feature was created by the current THP or NTMP project.[10]

LANDING METHODS

Site Identification

The landing to be evaluated was located as previously described under Site Selection. Landing selection was important because it became the basis for locating random sites for the other sample features.

Landing Surface

The entire landing surface was inspected for rills and gullies. Gullies were defined as being six inches or greater in depth and of any length. The total length of all gullies and their average width and depth were recorded on the data forms. Sample points for rills were located along a single transect that bisected the landing into two roughly equal parts perpendicular to the general direction of surface runoff in 1996. The percentage of the landing surface drained by rills was estimated for 1997 through 2001. To be counted, rills had to be a least one inch deep and 10 feet long. Both rills and gullies were inspected to determine whether they continued for more than 20 feet past the toe of the landing fill slope, and gullies were followed to determine if sediment had been delivered to the nearest WLPZ and channel.

Cut Slopes (if present)

The face of the cut slope was inspected for evidence of slope failures, rilling, and gullying. The path of any transported sediment was traced to determine the quantity and whether material was transported to a drainage structure(s) on the landing.

[10] Number codes that were used to indicate erosion and problem feature date were: 1-feature created by current THP; 2-feature predates and was affected by current THP; 3-feature predates and was not affected by current THP; 4-cannot determine feature date; and 5-feature created after THP but was not affected by THP. For example, 1-R indicated that a rill was created by the current THP or NTMP project.

Fill Slopes (if present)

The toe of the fill slope was inspected for evidence of slope failures, rilling, and gullying. Rills or gullies that were not caused by drainage from the landing surface were traced to determine whether they extended to a downslope channel. All slope failures were evaluated to determine the total amount of material moved and whether it reached a watercourse channel.

WATERCOURSE CROSSING METHODS

Site Identification

A watercourse crossing site was established at the first crossing encountered on the road or skid trail transects, which was also noted as a feature on the transect. If no crossing was encountered as part of the transects, the first crossing beyond the end of the road transect was used for this evaluation.

Once the crossing had been identified, the next step was to determine the length of road to be included in the drainage evaluation. This was done by walking in both directions from the crossing and identifying the points where runoff from the road surface, cuts, and fills no longer carried toward the stream crossing. The road length for evaluation also included the cut-off waterbar that should route water away from the crossing.

Fill Slopes

The crossing fill slope was evaluated to determine whether it had vigorous dense cover or if at least 50 percent of its surface was protected by vegetation, mulch, rock, or other stable material. The presence and frequency of rills, gullies, and cracks or other indicators of slope failure were noted, and the size of rills and slope failures was recorded.

Road Surface

The type and condition of road surfacing was assessed and was evaluated for ruts from vehicles and, if ruts were present, whether they impaired road drainage. The presence, frequency and length of rills and gullies on the road surface were also determined along with average gully size and surface drainage conditions. The presence, condition, and effectiveness of cutoff waterbars and inside ditches were evaluated, along with evidence of ponding or other water accumulation on the road.

Culverts

The stream channel at both the culvert inlet and outlet was examined for evidence of scouring. The current degree of plugging at the upstream inlet was assessed along with the diversion potential in case the culvert eventually becomes plugged. Alignment of the culvert, crushing of the inlet and outlet, and degree of corrosion were also evaluated. Pipe length and gradient were determined and evidence of piping around the culvert was identified.

Non-Culvert Crossings (e.g., Rocked Class III crossings)

The crossing was examined to determine the type and condition of armoring and whether downcutting or scouring at the outlet was occurring. Crossing approaches were evaluated to determine if they had been maintained to prevent diversion of stream overflow down the road should the drainage structure become plugged.

Removed or Abandoned Crossings (where applicable)

Removed crossings were examined to determine whether the restored channel configuration was wider than the natural channel and as close as feasible to the natural watercourse grade and orientation. The location of excavated material and any resulting cut bank was assessed to determine if they were sloped back from the channel and stabilized to prevent slumping and minimize erosion. The crossing was also evaluated for the following conditions:

- Permanent, maintenance free drainage.
- Minimizing concentration of runoff, soil erosion and slope instability.
- Stabilization of exposed soil on cuts, fills or sidecast that prevents transport of deleterious quantities of eroded surface soils to a watercourse.
- Grading or shaping of road surfaces to provide dispersal of water flow.
- Pulling or shaping of fills or sidecast to prevent discharge of materials into watercourses due to failures of cuts, fills or sidecast.

WATERCOURSE PROTECTION ZONE (WLPZ, ELZ, EEZ) TRANSECT METHODS

Transects

Two Class I or II WLPZs were sampled on each THP or NTMP project, when available (transects may have been shorter than 1000 feet, but must have been at least 500 feet to be included). These WLPZ segments were located along the nearest, accessible Class I or II watercourse relative to the selected landing sites. When WLPZs were present near only one of the selected landings, both segments were selected from this location. And where there was only one WLPZ on the THP, both segments could have been located along the same watercourse but, where possible, should have represented different conditions (e.g., different stream classes, stream gradients, sideslope gradients, adjacent logging methods, etc.).

For Class I waters, two 1000 foot long transects were sampled parallel to the stream within the WLPZ. One of these was a "mid-zone" transect located between the watercourse bank and the up-slope boundary of the WLPZ. The other was a "streambank" transect located immediately along the stream bank and parallel to the mid-zone transect. For Class II watercourses, only the mid-zone transect was used.

Beginning in 2000, Class III watercourses were included in the Hillslope Monitoring Program. Two Class III watercourses were sampled on each THP or NTMP project, when available. One 300 foot long transect parallel to the watercourse was established for each Class III evaluated. These segments were located along the nearest, accessible Class III watercourse relative to the selected landing sites. The transect was located either: 1) approximately 25 feet from the watercourse where no WLPZ had been established, or 2) where there was a designated protection zone (i.e., WLPZ, ELZ, or EEZ), along the “mid-point” of the designated zone. Class III monitoring protocols were developed in 1999 during a pilot project involving the THPs sampled as part of the 1999 Hillslope Monitoring Program work (Poff and Kennedy 1999).

<u>Data Recording</u>

Within the transects, groundcover and canopy cover were evaluated at regular intervals and at disturbed sites where timber operations had exposed more than 800 continuous square feet of mineral soil. Several other factors were also evaluated wherever they occurred, such as sediment delivery to the channel, streambank disturbance, and channel conditions.

Parameters measured or estimated in the mid-zone transect for Class I and II watercourses included groundcover at every 100 feet, canopy cover at every 200 feet with a spherical densiometer (from 1996 to 1998),[11] WLPZ width at every 200 feet (concurrent with canopy measurement and whenever there was a change in sideslope class), and sediment to the channel wherever it occurred. Measurements in the Class I watercourse streambank transect included canopy cover at 200 foot intervals, disturbance to streambanks wherever it occurred, and other stream related features. In addition, Rule implementation was evaluated continuously along both transects, and any Rule requirements or discrepancies were noted as a feature and were included in the implementation evaluation.

From 1999 to 2001, the canopy sampling method for Class I and II watercourses was changed from use of the spherical densiometer (Figure 5) to use of the sighting tube (Figures 6 and 7). This change was based on findings from a recent study that the sighting tube provides unbiased estimates of true canopy cover, while the densiometer does not (Robards et al. 2000). The procedure for estimating canopy was as follows:

[11] In 1996, the spherical densiometer was used as suggested by Lemmon (1956). The Strickler (1959) modification, which requires counting only 17 grid intersections, was used in 1997 and 1998 to reduce bias.

- Estimate the length of the WLPZ segment to be evaluated to the nearest 100 feet (maximum length was 1000 feet and minimum length was 500 feet). A 200 foot segment was randomly selected from the number of feet in this estimate.

- Canopy was estimated at 44 to 56 systematically located points throughout the 200 foot transect, where the number of points was based on the WLPZ width at the site. Sighting tube lines were run by “zig-zagging” back and forth across the WLPZ (i.e., up and down the hillslope) (see Figure 8).

- A random starting point for the first canopy point was used to reduce sampling bias.

- After leveling the sighting tube in both horizontal and vertical directions, a “hit” or a “miss” was recorded for that point depending on whether the small dot in the center of viewing area appeared to be touching or not touching some form of vegetation.

- The percent canopy for the transect was determined by the total number of “hits” for the transect divided by the total number possible (44 to 56).

The general procedure for recording watercourse protection zone transect data and the use of codes was similar in format to the methods used for roads and skid trails, but with features that were specific to watercourse protection zone conditions and Rule requirements. As with roads, the starting and ending distance to each feature was recorded along with a unique identification number and information about feature type, erosion causes, dimensions of erosion features, and sediment deposition. Additionally, a feature date code was included for all erosion features and other features related to Rule requirements to indicate if the feature was created by the current THP or NTMP project (see footnote number 10).

Groundcover was estimated in an area with a diameter of approximately one foot located directly in front of the observer’s boot toe, where adequate cover was defined as "living plants, stumps, slash, litter, humus, and surface gravel (minimum diameter of 3/4 inch) in amounts sufficient to break the impact of raindrops and serve as a filter media for overland flow.”

Features did not need to intersect the transect line to be included. This was necessary because dense vegetation and other obstructions in watercourse protection zones make following a straight line transect impractical, so the location of the transect line will be biased by access within the zone and some extensive watercourse protection zone features might not intersect the transect. An example of this situation would be a road running parallel to, but not on, the transect.

The Class I and II WLPZ measurements began at one end of the mid-zone transect and included a continuous record of the beginning and end points of features encountered along the transect for a distance perpendicular to the end of the mid-zone transect and proceeded in the opposite direction toward the starting point of the mid-zone transect.

Figure 5. Concave spherical densiometer used for canopy measurements from 1996 to 1998 (the Strickler (1959) modification was utilized in 1997 and 1998 to reduce bias).

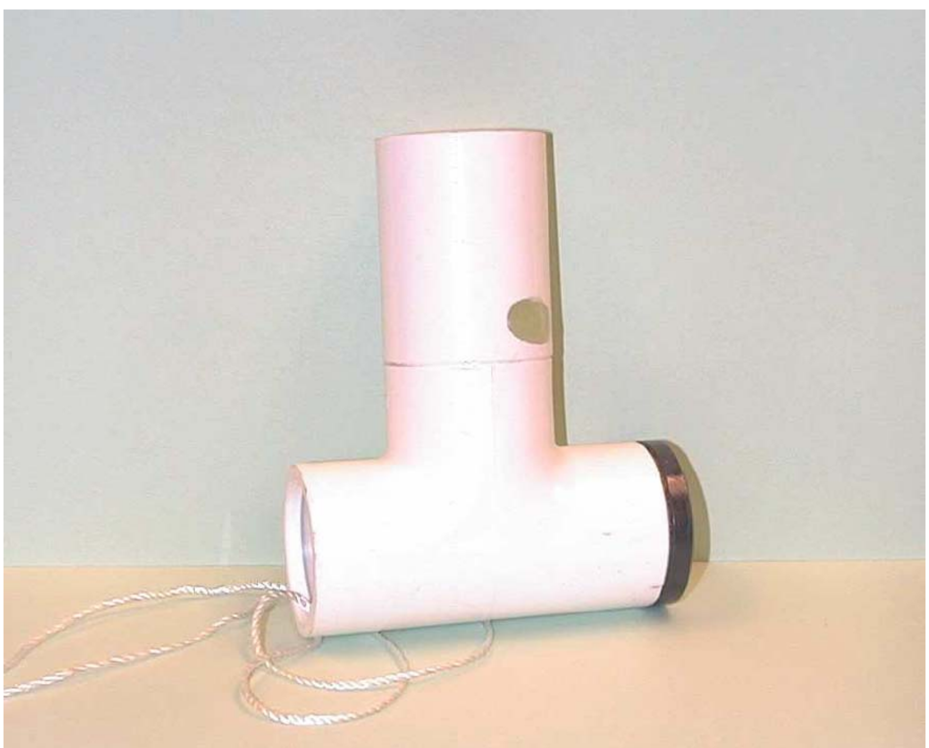

Figure 6. Close-up view of the sighting tube.

Figure 7. The sighting tube in use in the field. This instrument was utilized for obtaining an unbiased estimate of canopy cover from 1999 through 2001.

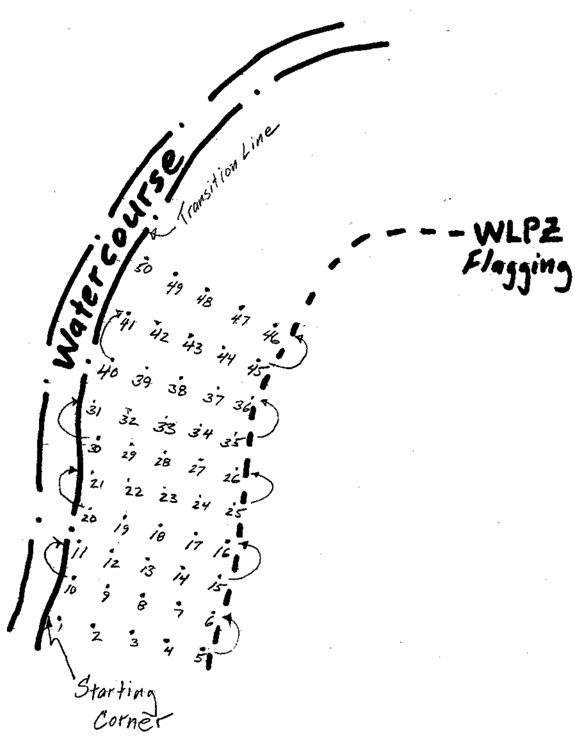

Figure 8. Example of the systematic grid used for a 125-foot WLPZ to determine canopy cover with a sighting tube for a randomly selected 200 foot reach of Class I or II watercourse (total number of sighting tube points varied from 44 to 56 depending on WLPZ width). Diagram drawn by Mr. Clay Brandow, CDF, Sacramento.

For Class III watercourses, ground cover was evaluated every 100 feet, including end points, and at the mid-points of disturbed sites. ELZ, EEZ, or WLPZ widths were determined every 100 feet, including end points. Erosion features were recorded and sediment delivery to channels was documented where it occurred. Canopy was not measured, but where canopy was retained, it was noted with the appropriate code.

LARGE EROSION EVENT EVALUATION METHODS

Erosion events that created voids larger than 100 cubic yards were assessed whenever they were encountered on the THP on NTMP project. For watercourse crossings that had failed, a large erosion event was defined as greater than 10 cubic yards. These sites were identified during the standard site evaluations, while traveling within the THP, or as a result of information provided in the THP or by landowners or managers. Data collected included the location, size, and type of feature; site conditions; and an evaluation of the causal connections between the feature and specific timber operations, along with any applicable Forest Practice Rules. Features were classified as gullies, shallow debris slides, debris torrents, deep seated rotational failures, streambank failures, or catastrophic crossing failures. This process was modified significantly in 1997 based on information provided by the Hillslope Monitoring Program contractors who completed the field work in Mendocino and Humboldt Counties during 1996.

If more than five large erosion events were discovered on a THP or NTMP, only the first five were required to be completely evaluated by the field team. For additional events, only the location, type, and estimate of the cause were briefly noted.

NON-STANDARD PRACTICES AND ADDITIONAL MITIGATION MEASURE METHODS

In addition to completing the site information, implementation, and effectiveness sections of the field forms, the field teams also filled out a form for non-standard practices and additional mitigation measures, for each of the five subject areas.[12] Non-standard practices include in-lieu and alternative practices. These site specific practices and/or additional mitigation measures often did not apply at the randomly selected transects and features, so the totals reported are a relatively small sample that does not include all of the types of practices that were included in the THPs and NTMP projects.

For each of the five evaluation areas (roads, skid trails, landings, watercourse crossings, and watercourse protection zones), four questions were asked:

1. Was an alternative, non-standard, or in-lieu practice approved on the THP or NTMP NTO?

[12] Non-standard practices, alternatives, in-lieu, and exception practices are defined in the Glossary.

2. Were additional mitigation measures beyond the standard Rules included in the approved THP or NTMP NTO?

3. Where present on the sample transect or feature, have the alternative measures been implemented as described in the THP or NTMP NTO?

4. Provide comments on the implementation and effectiveness of the alternative practices.

The field team provided brief qualitative answers to these questions where they were applicable to the randomly located sites being evaluated.

TOTAL SAMPLE SIZE FOR THE PERIOD FROM 1996 TO 2001

If qualifying features had been found for all the THPs and NTMP projects sampled (and all the plans had been tractor yarded), the total sample size would have equaled the "maximum possible" number illustrated in Table 4. The actual sample size, however, is lower (as shown in Table 4) because numerous smaller plans did not have two of each feature to sample and many of the plans were entirely yarded with aerial systems (i.e., cable or cable/helicopter).

Table 4. Potential and actual sample sizes for the Hillslope Monitoring Program from 1996 through 2001.

	Road Segments	**Skid Trail Segments**	**Landings**	**Watercourse Crossings**	**Class I and II WLPZs**[13]	**Class III ELZs, EEZs, WLPZs**
Maximum Possible	600	600	600	600	600	200
Actual Number Sampled	568	480	569	491	501	182

[13] This column includes three Class IV watercourses.

Results

The results of the Hillslope Monitoring Program reported here are organized using the following major categories: roads, skid trails, landings, watercourse crossings, watercourse protection zones, large erosion events, and non-standard practices/additional mitigation measures. The results are generally displayed in a manner similar to that used in the earlier interim Hillslope Monitoring Program Report (CSBOF 1999).

Roads

From 1996 through 2001, 568 randomly located road transects were evaluated, covering a total of approximately 550,200 feet or 104.2 miles. Over 80 percent of the road transects were classified as seasonal roads (Table 5). About 23.4 percent of the road length surveyed had been surfaced with rock. Approximately 81 percent of the road transects monitored were existing roads built prior to the current plan; 19 percent of the transects were classified as new roads.

As part of the road transects, the field team rated the implementation and effectiveness of applicable Forest Practice Rules as they were encountered and as part of an overall evaluation following completion of the transect. In the overall evaluation of road transects, a total of 59 questions were answered in the field based on 46 Forest Practice Rule sections, since some FPRs were broken down into separate components. The majority of the Rules had high percentages (i.e., greater than 90 percent) of cases where implementation ratings either met or exceeded the standard Rule requirements. When considering all the Forest Practice Rules related to roads, the implementation rate where the Rules were met or exceeded was **93.2** percent. For the Forest Practice Rules where the sample size was adequate[14], 23 Rule requirements were found to have combined minor and major departures greater than five percent (Table 6).

Table 5. Percentages of road segment type.

Road Segment Type	Percent
Permanent	10
Seasonal	84
Temporary	4
Combination	2

[14] The results reported here are based on at least **30** observations where the field team assigned an implementation rating of exceeded rule requirement, met requirement, minor departure from requirement, or major departure from requirement. Thirty observations represents five percent or more of the implementation ratings available for each major category (i.e., roads, skid trails, landings, watercourse crossings, and watercourse protection zones).

Table 6. Road related Forest Practice Rule requirements with more than five percent departures based on at least 30 observations from the overall transect evaluation where implementation could be rated (note that some Rule sections are divided into components and the table is ordered by the percentage of total departures).

Forest Practice Rule	Description	Total Number	% Total Departure	% Minor Departure	% Major Departure
923.4(c)	waterbreaks maintained to minimize erosion	458	24.2	22.1	2.2
914.6(f)	where waterbreaks do not work—other erosion controls installed	214	19.2	15.0	4.2
923.1(f)	adequate numbers of drainage structures to minimize erosion	567	18.3	13.6	4.8
923.2(h)	size, number, and location of structures sufficient to carry runoff water	564	17.6	12.2	5.3
914.6(c)	waterbreak spacing according to standards in 914.6(c)	452	17.5	14.8	2.7
914.6(g)	waterbreaks have embankment of at least 6 inches	438	17.4	14.6	2.7
923.1(a)	landings on roads greater than ¼ acre or requiring substantial excavation must be shown on the THP map	243	15.2	3.7	11.5
923.2(h)	size, number, and location of structures sufficient to minimize erosion	565	15.2	11.2	4.1
914.6(g)	waterbreaks cut to depths of at least 6 inches	443	15.1	12.6	2.5
923.2(b)	sidecast minimized for slopes greater than 65% and distances greater than 100 feet	66	13.6	13.6	0.0
923.2(o)	discharge onto erodible fill prevented	510	13.1	9.2	3.9
923.2(d) Coast District	fills constructed with insloping approaches, berms, rock armoring, etc.	192	13.0	8.3	4.7
923.2(m)	sidecast extending greater than 20 feet treated to avoid erosion	202	11.9	4.5	7.4
914.6(f)	waterbreaks built to discharge into cover	464	11.4	9.3	2.2
923.2(d) Northern/ Southern	breaks in grade for drainage are located above and below through-fill, or other measures provided to protect the fill	222	11.3	8.6	2.7
923.6	wet spots rocked or otherwise treated	318	10.4	9.7	0.6
923.2(l)	trash racks, etc. installed where appropriate	173	9.2	6.4	2.9
923.2(p)	waterbars installed according to 914.6	401	8.7	6.5	2.2
923.4(j)	drainage ditches maintained to allow flow of water	306	8.5	8.2	0.3
923.1(d)	slopes greater than 65%, 50% within 100 feet of WLPZ--treat soil	93	7.5	5.4	2.2
923.4(c)	erosion controls maintained during the maintenance period	177	5.6	4.5	1.1
923.1(g)(3)	insloped roads-adequate number of ditch drains installed	237	5.5	4.6	0.8
923.4(e)	roadside berms removed or breached	513	5.5	5.3	0.2

The Rules with the highest percentages of total departures were related to waterbreak maintenance; use of other erosion control measures when waterbreaks are not effective; use of adequate numbers of drainage structures to minimize erosion; sufficient size, number, and location of drainage structures to carry runoff water; and waterbreak spacing. All the Rules evaluated had major departure percentages of less than five percent except for three: 1) if the landing on road was greater than ¼ acre or had substantial excavation, it must be shown on THP map; 2) sidecast extending greater than 20 feet must be treated to avoid erosion, and 3) the size, number, and location of drainage structures must be sufficient to carry runoff water.

A total of 1,132 erosion features were noted on the road transects. These features included rilling, gullying, mass failures, cutbank/sidecast sloughing, and other erosion types. Gullies were defined as erosion channels deeper than six inches, while rills were defined as small surface erosion channels that: 1) were greater than two inches deep at the upslope end when found singly or greater than one inch deep where there were two or more, and 2) were longer than 20 feet if located on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Mass failures were defined as downslope movement of soil and subsurface material that occurs when its internal strength is exceeded by the combination of gravitational and other forces. Mass erosion processes include slow moving, deep-seated earthflows and rotational failures and rapid, shallow failures on hillslopes (debris slides) and in downstream channels (debris torrents). Sloughing was defined as shallow, surficial sliding associated with either the cutbank or fill material along a forest road or skid trail, with smaller dimensions than would be associated with mass failures.

The distribution of erosion features is displayed in Table 7. Total erosion volumes from cutbank/sidecast sloughing, mass failure, and gullying is estimated to be roughly 3,600; 76,200; and 2,500 cubic yards, respectively.[15] This equates to approximately 790 cubic yards per mile.[16] Of the mass failures, one feature (450 feet x 270 feet x 15 feet) accounted for 88.6 percent of the total mass failure volume.[17] Without including this large feature, the average erosion volume is reduced to 142 cubic yards per mile. These estimates are based on the volumes of voids remaining at the hillslope locations, not the amount of sediment delivered to watercourse channels. Table 7 also shows the

[15] Note that rilling volumes were not determined. Erosion from rilling is generally a much smaller component of total hillslope erosion when compared to that from mass wasting and gullying. For example, Rice et al. (1979) found that rilling accounted for only three percent of the total hillslope erosion following tractor logging in the South Fork Caspar Creek watershed. Rice and Datzman (1981) reported rill erosion to be eight percent of the total erosion measured in northwestern California.

[16] Measuring only erosion voids of 13 cubic yards or more, Rice and Lewis (1991) reported that the average road erosion rate measured in the Critical Sites Erosion Study was 524 cubic yards/mile for their North Coast analysis unit (rain-dominated portions of the North Coast with redwood and Douglas-fir).

[17] This mass wasting feature was classified as a deep seated rotational failure on 70 percent slopes and located in the Northern Forest Practice District. Management related factors included waterbar discharge onto erodible material and subsurface water concentration.

number of erosion features recorded in the first three year period (1996 through 1998) and the second three year period (1999 through 2001). For all types of erosion features, the numbers are lower for the 1999 through 2001 period. Possible reasons for this difference are presented in the Discussion and Conclusions section of this report.

Table 8 shows the percentage of road transects with one or more erosion features of a given erosion type. Almost half the road transects had at least one rill, roughly a quarter of the transects had one or more gullies, and about four percent had at least one mass failure.

When an erosion problem feature or other type of problem (such as inadequate waterbar construction, tension cracks in the road surface, etc.) was discovered, implementation of the applicable Forest Practice Rule(s) was also rated for that problem point. A total of 40 Rule requirements were rated for implementation at problem sites along the road transects. Of these, 21 Rules were associated with approximately 95 percent of the problem points (Table 9). The most commonly cited Rules were: 1) sufficient size, number, and location of drainage structures to carry runoff water, 2) adequate numbers of drainage structures to minimize erosion, and 3) sufficient size, number, location of drainage structures to minimize erosion. As was reported in the interim Hillslope Monitoring Program report (CSBOF 1999), the vast majority of problem

Table 7. Road transect erosion features related to the current THP or NTMP project.

Erosion Feature	Number of Features 1996-1998	Number of Features 1999-2001	Total Number of Features 1996-2001
Cutbank/sidecast Sloughing	80	48	128
Mass Failure	18	12	30
Gullying	148	120	268
Rilling	478	225	703
Other Erosion Features	3	0	3
Totals	727	405	1,132

Table 8. Percent of road transects with one or more erosion features associated with the current plan for selected types of erosion features.

Erosion Feature	Percent of Transects with One or More Features
Sloughing	12.2
Mass Failures	3.9
Gullying	25.5
Rilling	48.9

points recorded along the road transects were judged to be due to either minor or major departures from specific Rule requirements. When considering all the implementation ratings assigned at problem points, only about two percent were associated with situations where the Rule requirements were judged to have been met or exceeded and 98 percent were associated with departures from Rule requirements.

Table 9. Problem point implementation ratings that account for approximately 95 percent of all the Forest Practice Rule requirements rated along road transects.

Forest Practice Rule	Description of Rules Rated for Implementation at Problem Points	Number of Times FPR Cited	Meets/ Exceeds Rule (%)	Minor Departure (%)	Major Departure (%)
923.2(h)	size, number, and location of structures sufficient to carry runoff water	452	0.2	80.8	19.0
923.1(f)	adequate numbers of drainage structures to minimize erosion	438	2.7	78.8	18.5
923.2(h)	size, number, and location of structures sufficient to minimize erosion	401	4.7	78.3	17.0
914.6(f)	waterbreaks built to discharge into cover	236	0.0	87.3	12.7
914.6(c)	waterbreak spacing according to standards in 914.6(c)	234	5.1	78.6	16.2
923.2(o)	discharge onto erodible fill prevented	217	0.0	85.7	14.3
914.6(g)	waterbreaks have embankment of at least 6 inches	186	0.0	86.6	13.4
923.4(c)	waterbreaks maintained to minimize erosion	186	0.0	75.3	24.7
914.6(g)	waterbreaks cut to depths of at least 6 inches	166	0.0	84.3	15.7
923.2(p)	waterbars installed according to 914.6	89	6.7	74.2	19.1
914.6(f)	where waterbreaks do not work--other erosion controls installed	67	0.0	73.1	26.9
923.4(l)	soil stabilization on cuts, fills, sidecast	59	1.7	83.1	15.3
923.4(m)	inlet/outlet structures/additional structures have been maintained	38	0.0	84.2	15.8
923.2(m)	sidecast extending greater than 20 feet treated to avoid erosion	31	0.0	22.6	77.4
923.4(j)	drainage ditches maintained to allow flow of water	28	10.7	85.7	3.6
914.6(f)	waterbreaks built to provide unrestricted discharge	26	0.0	80.8	19.2
923(d)	road located to avoid unstable areas	24	0.0	87.5	12.5
923.4(c)	erosion controls maintained during maintenance period	20	0.0	70.0	30.0
914.6(f)	waterbreaks built to spread water to minimize erosion	19	0.0	68.4	31.6
923.2(g)	excess material stabilized so as to avoid impact	19	0.0	36.8	63.2
923.2(k)	road constructed without overhanging banks	19	0.0	100.0	0.0

The results displayed in Table 9 may be biased by the design of the program. Lewis and Baldwin (1997) suggested in their statistical review of this project that implementation should be rated immediately following the completion of logging and prior to stressing storm events to provide an unbiased assessment of whether a practice was implemented correctly. That is, it is likely that some percentage of the problem points might not have been classed as Rule departures if they had been evaluated at the end of timber operations. CDF's Modified Completion Report monitoring will provide information on implementation following harvesting that may help us address this concern. The logistics and funding of the current version of the Hillslope Monitoring Program did not allow for two site visits by the contractor.

The data collected along road transects allows us to determine the proportion of problem features versus non-problem features, particularly for road drainage structures. The counts of existing road drainage structures with and without problem points is displayed in Table 10. For the total population of waterbreaks evaluated, approximately seven percent did not conform to Rule requirements or had an associated erosion feature. Rolling dips and culverted cross drains had deficiencies about five percent of the time. Note that multiple types of Rule requirement violations are possible at each drainage structure with a problem. Therefore the number of drainage structures with problems will be less than the counts for major and minor Rule departures. Additionally, the number of structures with problems is lower than the counts for Rule departures since Rule implementation was rated whenever there was an erosion feature present, regardless of whether or not it was associated with a specific drainage structure.

Table 10. Counts of drainage structures evaluated along road transects with and without problem points.

Drainage Structure Type	Total Number	Number with No Problems	Number with Problems	Percent with Problems
Waterbreaks	1,879	1,756	123	6.5
Rolling Dips	605	578	27	4.5
Leadoff Ditch	315	309	6	1.9
Culvert Cross Drain	306	291	15	4.9
Other Drainage Structure	39	38	1	2.6
Totals	3,144	2,972	172	5.5

The source, cause, and depositional area associated with the recorded erosion features were also documented during the evaluations of the road transects. The different erosion types and their dominant source areas are displayed in Table 11. Cutbank and sidecast sloughing features were primarily associated with road cut slopes, with a smaller component coming from fill slopes. Mass failures were mostly associated with fill slopes below roads. Gullying had many source areas, but was most commonly

Table 11. Number of source location codes and the number delivering sediment to the high or low flow channel for the recorded erosion features associated with the current THP or NTMP NTO on road transects.

Source Area	Sloughing		Mass Failure		Gullying		Rilling	
	#[1]	# with delivery[2]	#[1]	# with delivery[2]	#[1]	# with delivery[2]	#[1]	# with delivery[2]
Cut Slope	68	1	6	0	4	1	5	2
Fill Slope	17	5	15	9	54	18	30	5
Hillslope Above Road	4	0	6	2	7	3	10	1
Hillslope Below Road	1	0	0	0	0	0	0	0
Road Surface	1	0	2	1	45	18	542	66
Waterbar Ditch	0	0	0	0	7	1	5	3
Waterbar Outlet	1	0	0	0	96	12	61	6
Inside Ditch	0	0	0	0	20	4	15	3
Rolling Dip Ditch	0	0	0	0	3	3	5	1
Rolling Dip Outlet	0	0	0	0	26	4	7	0
Other Erosion Source	0	0	0	0	5	2	6	0
Totals	**92**	**6**	**29**	**12**	**267**	**66**	**686**	**87**

[1]Totals in Table 11 differ from Table 7 because of missing source code data.
[2]Corrected for missing data.

associated with waterbar outlets, fill slopes, and the road surface. Rilling, in contrast, was almost always associated with the road surface.

The causes of the recorded erosion features are shown in Table 12. Dominant causes for cutbank and sidecast sloughing included the cutslope being too tall, unstable terrain, the cutslope being too steep, steep side slopes, and unstable fill. The most commonly cited causes of mass failures along the road transects were unstable terrain, unstable fill, and steep side slopes. Approximately 85 percent of the gullies recorded were judged to be caused by drainage feature problems. Similarly, about 70 percent of the rills documented were coded as being associated with drainage feature problems. When rills occurred with road drainage structures (i.e., waterbreaks, rolling dips, lead off ditches) located somewhere along the length of the rill, the rill ended at the drainage structure 57 percent of the time. Highly erodible surface material and steep road gradient were also frequently cited causes of rilling.

Because drainage feature problems are the major cause associated with gullying and rilling on the road transects (Table 12), additional detail for this category is shown in Table 13. For gullying, cover (drainage structure did not discharge into vegetation, duff, slash, rocks, etc.) and spacing of drainage features (too far apart) were the most frequently cited problems. Inappropriate spacing of drainage structures was cited approximately 60 percent of the time for drainage feature problems associated with rilling. Also commonly recorded were inappropriate location to capture surface runoff and inadequate cover. Mass failures were usually not associated with drainage feature problems. When they were, inadequate cover and cross drain culvert shotgun outlets without adequate armoring at the point of discharge were the most frequent codes cited.

Similarly, cutbank or sidecast sloughing was usually not associated with a drainage feature problem. When it was, traffic impact on drainage structure function was the most frequently recorded problem.

Table 12. Number of recorded erosion cause codes related to development of identified erosion features associated with the current THP or NTMP NTO on road transects (note that multiple cause codes can be assigned to a single erosion feature).

Erosion Cause	**Sloughing**		**Mass Failure**		**Gullying**		**Rilling**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Fill Slope too Long	1	1	0	0	0	0	1	0
Cut Slope too Steep	20	17	3	6	2	1	1	0
Cut Slope too Tall	35	29	5	9	0	0	2	0
Drainage Feature Problem	3	3	4	8	239	85	538	72
Highly Erosive Surface Material	8	7	3	6	16	6	99	13
Steep Side Slopes	13	11	9	17	1	0	15	2
Unstable Fill	13	11	12	23	5	2	1	0
Unstable Terrain	22	18	13	24	1	0	1	0
Rutting	0	0	0	0	3	1	27	4
Steep Road Gradient	0	0	0	0	5	2	52	7
Other Erosion Cause	4	3	4	7	8	3	13	2
Totals	119	100	53	100	280	100	750	100

Table 13. Number of drainage feature problems associated with erosion features on road transects (note that multiple drainage feature problem codes can be assigned to a single erosion feature).

Drainage Feature Problem	**Sloughing**		**Mass Failure**		**Gullying**		**Rilling**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Blocked Ditch	2	9	0	0	4	1	6	1
Cover	4	17	2	29	142	34	86	10
Flow	3	13	0	0	9	2	7	1
Shotgun Outlet without Armoring	1	4	2	29	2	0.5	2	0
Location Inappropriate	2	9	0	0	81	20	110	13
Spacing	2	9	0	0	129	31	480	57
Divert	0	0	0	0	12	3	42	5
Runoff Escaped	0	0	0	0	5	1	7	1
Maintenance	0	0	1	14	11	3	47	6
Plugged Inlet	0	0	1	14	2	0.5	0	0
Rolling Dip Break	0	0	0	0	3	1	4	0.5
Height	0	0	0	0	0	0	3	0.5
Traffic	5	22	1	14	3	1	34	4
Other	4	17	0	0	10	2	7	1
Totals	23	100	7	100	413	100	835	100

Whether sediment actually reached a watercourse from the erosion features found along the road transects is of critical concern to the protection of beneficial uses of water. Figure 9 shows the percentage of identified erosion features that delivered sediment to channels. Since winter documentation of fine sediment delivery to streams was not possible with this program, the percentages of sediment delivery to the high or low flow channel displayed in Figure 9 are likely to underestimate total sediment delivery. The field team attempted to document the closest approach of sediment from a given erosion feature to the watercourse it was directed toward, using field evidence remaining in the dry spring, summer, and fall months. This evidence included: 1) fine and coarse sediment deposition on the forest floor, and 2) rill or gully discharge directly into the high or low flow channel.

The sediment delivery percentages to the high flow channel are similar to those reported in the interim Hillslope Monitoring Program report, after the evaluation of 150 THPs (CSBOF 1999). In that report, it was stated that the percentage of sloughing, mass failures, gullying, and rilling features delivering sediment to the channel was 6 percent, 47 percent, 18 percent, and 13 percent, respectively. Following the evaluation of 300 projects, the percentages of sediment delivery to the high or low flow channel for sloughing, mass failures, gullying, and rilling features are 6.2 percent, 39.3 percent, 24.5 percent, and 12.6 percent, respectively (Figure 9). No sediment was transported to the channel for 93.8 percent of the sloughing features, 60.7 percent of the mass wasting features, 75.5 percent of the gullies, and 87.4 percent of the rills. Of the rills that delivered sediment to watercourses, 70.2 percent delivered to Class III watercourses. For gullies that delivered sediment, 49.2 percent input sediment to Class III watercourses. Sediment delivery data was not reported for 4.8 percent of the rilling features, 1.1 percent of the gullies, 6.7 percent of the mass failures, and 23.4 percent of the sloughing events.

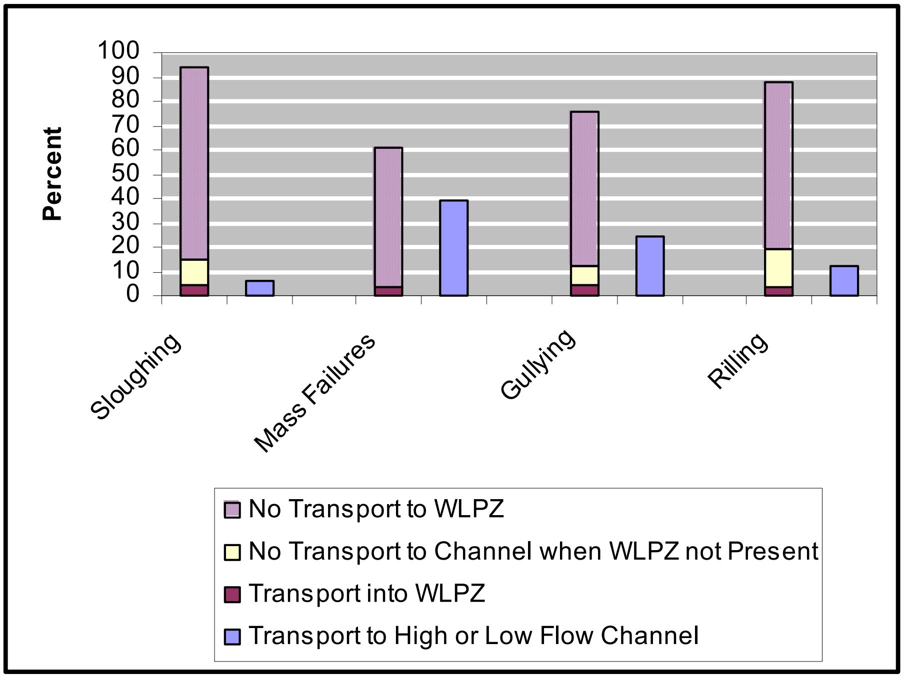

Figure 9. Percent of erosion features with dry season evidence of delivered sediment to the high or low flow channel of a watercourse from road transect erosion features related to the current THP or NTMP NTO.

Skid Trails

From 1996 through 2001, 480 randomly located skid trail transects were evaluated, covering a total of approximately 352,000 feet or 66.7 miles. The time of logging operations for approximately 90 percent of the skid trail transects was judged to be the dry season, with eight percent classified as winter operations, and two percent as either a combination of the wet and dry seasons or unknown. The silvicultural systems associated with the sampled skid trail transects were: 33% selection, 14% alternate prescription, 13% clearcut, 10% shelterwood, 9% commercial thinning, 5% transition, 4% seed tree, 2% sanitation salvage, and 2% rehabilitation, with 8% having combinations of silvicultural systems.[18] Data was not recorded on whether the skid trails were existing prior to the operation of the plan or created as part of the current project. The overall sample size (480 skid trails) is considerably lower than that for road transects because some of the THPs were entirely cable yarded. Field procedures and forms for skid trails are similar to those used for roads, so the results are presented in a similar manner.

As part of the skid trail transects, the field team rated the implementation and effectiveness of applicable Forest Practice Rules as they were encountered, and as part of an overall evaluation following completion of the 500 to 1,000 foot transects. A total of 26 questions were developed to answer in the field based on 22 Forest Practice Rule sections, since some Rules were broken down into separate components. In the overall evaluation of skid trail transects, the Rules were met or exceeded **95.1** percent of the time. For Forest Practice Rules where the sample size was adequate (i.e., 30 observations), seven Rule requirements were found to have combined minor and major departures greater than five percent (Table 14). The highest percentage of total departures from Forest Practice Rule requirements were for Rules requiring the installation of other erosion control structures where waterbreaks cannot disperse runoff, waterbreak spacing, and waterbreak maintenance. All the Forest Practice Rules evaluated had major departure percentages of less than five percent except for one: waterbreak spacing equals the standards specified in 14 CCR 914.6 (934.6, 954.6).

A total of 203 erosion features were found on the skid trail segments. The number of these features for each erosion type and observation period is shown in Table 15. Rilling accounted for more than 70 percent of the number of features. The total erosion volumes from cutbank/sidecast sloughing, mass failures, and gullying is estimated to be roughly 5, 1100, and 400 cubic yards, respectively. As was the case for the road transects, these volume estimates are based on the dimensions of voids remaining on the hillslopes, not the amount of sediment delivered to watercourse channels. Also similar to what was reported for the road transects, the number of erosion features for all types of erosion were lower in the period 1999 through 2001 than from 1996 to 1998. Possible reasons for this difference are given in the Discussion and Conclusions section of this report.

[18] Some skid trails were obliterated during site preparation activities.

The percentage of skid trail transects that had one or more erosion features of a given erosion type is shown in Table 16. Approximately 20 percent of the transects had at least one rill recorded, about seven percent had one or more gullies, and one percent had at least one mass failure.

Table 14. Skid trail related Forest Practice Rule requirements with more than 5 percent total departures based on at least 30 observations from the overall transect evaluation where implementation could be rated (note that some of the Rule sections are separated into components and the table is ordered by the percentage of total departures).

Forest Practice Rule	Description	Total Number	% Total Departure	% Minor Departure	% Major Departure
914.6(f)	where waterbreaks cannot disperse runoff, other erosion controls installed as needed	158	20.3	17.7	2.5
914.6(c)	waterbreak spacing equals standards	467	19.3	13.7	5.6
923.4(c)	waterbreaks maintained to divert runoff water	444	10.6	9.9	0.7
914.6(g)	waterbreaks have embankment of 6 inches	445	7.4	6.1	1.3
914.6(e)	waterbreaks installed for natural channels	219	6.4	3.7	2.7
914.6(g)	waterbreaks cut to minimum depth of 6 inches	445	5.8	4.7	1.1
914.6(c)	waterbreaks installed at 100 foot intervals on cable roads	213	5.6	4.2	1.4

Table 15. Skid trail transect erosion features related to the current THP or NTMP project.

Erosion Feature	Number of Features 1996-1998	Number of Features 1999-2001	Total Number of Features 1996-2001
Cutbank/sidecast Sloughing	3	1	4
Mass Failure	6	1	7
Gullying	35	12	47
Rilling	104	41	145
Totals	148	55	203

Table 16. Percent of skid trail transects with one or more erosion features associated with the current plan for selected types of erosion features.

Erosion Feature	Percent of Transects with One or More Features
Sloughing	0.8
Mass Failures	1.0
Gullying	6.7
Rilling	19.2

As with the road transects, when an erosion feature or other problem was found along the skid trail transects, implementation of the applicable Forest Practice Rule(s) was rated for that problem point. A total of 12 Rule requirements were rated for implementation at skid trail problem sites. Of these, nine Rules were associated with over 95 percent of the problem points (Table 17). All but one of these problem points were related to either minor or major departures from specific Forest Practice Rule requirements. Therefore, only about 0.2 percent of problem points were associated with situations where the Rule requirements were judged to have been met or exceeded, and 99.8 percent were associated with minor or major departures from Rule requirements.

Table 17. Problem point implementation ratings that account for over 95 percent of all the Forest Practice Rule requirements rated along skid trail transects.

Forest Practice Rule	Description of Rules Rated for Implementation at Problem Points	Number of Times FPR Cited	Meets/ Exceeds Rule (%)	Minor Departure (%)	Major Departure (%)
914.6(c)	waterbreak spacing equal standards	106	0.0	87.7	12.3
914.6(g)	waterbreaks have embankment of 6 inches	72	0.0	95.8	4.2
923.4(c)	waterbreaks maintained to divert water	62	0.0	100.0	0.0
914.6(f)	if waterbreaks do not work, other structures stall be installed	48	0.0	91.7	8.3
914.6(g)	waterbreaks cut to minimum depth of 6 inches	48	0.0	100.0	0.0
914.6(f)	waterbreaks allow discharge into cover	42	0.0	100.0	0.0
914.6(f)	waterbreaks--unrestricted discharge	42	0.0	100.0	0.0
914.6(f)	waterbreaks spread water to minimize erosion	25	0.0	92.0	8.0
914.6(g)	waterbars placed diagonally	24	4.2	95.8	0.0

The proportion of skid trail drainage features with and without problems is shown in Table 18. Nearly all these drainage structures were waterbreaks, and approximately four percent of them did not conform to Rule requirements or had an associated erosion feature. The number of waterbreaks with specific associated problems is much lower than the total counts of Rules rated for implementation at problem points (Table 17) because: 1) multiple Rule deficiencies are possible at each drainage structure with a problem, and 2) Rule implementation was rated at each erosion feature on a skid trail transect, whether or not it was associated with a specific drainage structure.

Table 18. Counts of drainage structures evaluated along skid trail transects with and without problem points.

Drainage Structure Type	**Total Number**	**Number with No Problems**	**Number with Problems**	**Percent with Problems**
Waterbreaks	2,940	2,830	110	3.7
Rolling Dips	51	50	1	2.0
Other Drainage Structure	1	1	0	0
Totals	2,992	2,881	111	3.7

As with the road transects, the source, cause, and depositional site associated with a recorded erosion feature was documented during the evaluation of skid trail transects. Cutbank and sidecast sloughing originated entirely from cut slopes, while mass failures were mostly associated with cut and fill slopes (Table 19). Over 90 percent of rilling features and two-thirds of gullying events were associated with the skid trail surface. About 24 percent of the skid trail gullies were related to waterbreak ditches or outlets.

Table 19. Number of source location codes and the number delivering sediment to the high or low flow channel for the recorded erosion features associated with the current THP or NTMP NTO on skid trail transects.

Source Area	**Sloughing**		**Mass Failure**		**Gullying**		**Rilling**	
	#	**# with delivery**	**#**	**# with delivery**	**#**	**# with delivery**	**#**	**# with delivery**
Cut Slope	4	0	2	0	0	0	0	0
Fill Slope	0	0	2	0	0	0	0	0
Hillslope Above Road	0	0	0	0	2	0	1	0
Skid Trail Surface	0	0	1	0	31	5	123	5
Waterbar Ditch	0	0	0	0	4	0	3	0
Waterbar Outlet	0	0	1	0	7	1	4	0
Inside Ditch	0	0	0	0	1	1	1	0
Rolling Dip Ditch	0	0	0	0	1	0	0	0
Rolling Dip Outlet	0	0	0	0	0	0	1	0
Totals	4	**0**	6	**0**	46	**7**	133	**5**

Erosion cause codes associated with the skid trail transects are displayed in Table 20. Mass failures on skid trails were mostly related to unstable terrain and unstable fill. Drainage feature problems contributed to gullying approximately 65 percent of the time, with highly erodible surface material and steep trail gradient each being cited about 10 percent of the time. Drainage feature problems were related to rilling features about 70 percent of the time, with highly erodible surface material and steep trail gradient contributing to the cause of about 15 percent and eight percent of the rills, respectively.

A summary of drainage feature problems found on skid trails is shown in Table 21. Cutbank/sidecast sloughing and mass failures were not found to be related to drainage feature problems. Approximately half of the drainage feature problems related to skid trail gullying were attributed to inadequate spacing of drainage structures, with another 20 percent related to inappropriate locations of the drainage structures to capture surface runoff. Similarly, almost 60 percent of the drainage feature problems related to rilling were attributed to inadequate spacing, with 17 percent related to inappropriate locations of the drainage structures and 12 percent associated with the inability of the drainage structure to divert runoff fully off the trail surface.

Table 20. Number of recorded erosion cause codes related to development of identified erosion features associated with the current THP or NTMP NTO on skid trail transects (note that multiple cause codes can be assigned to a single erosion feature).

Erosion Cause	**Sloughing**		**Mass Failure**		**Gullying**		**Rilling**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Cut Slope too Steep	1	20	0	0	0	0	0	
Cut Slope too Tall	1	20	0	0	0	0	0	
Drainage Feature Problem	0	0	0	0	35	65	101	70
Highly Erosive Surface Material	2	40	1	8	5	9	22	15
Steep Side Slopes	1	20	2	15	2	4	2	1
Unstable Fill	0	0	3	23	3	5	1	1
Unstable Terrain	0	0	6	46	0	0	0	0
Rutting	0	0	0	0	0	0	1	1
Steep Skid Trail Gradient	0	0	0	0	5	9	12	8
Organic Matter in Fill	0	0	0	0	1	2	0	0
Other Erosion Cause	0	0	1	8	3	6	6	4
Totals	5	100	13	100	54	100	145	100

Table 21. Number of drainage feature problems associated with erosion features on skid trail transects (note that multiple drainage feature problem codes can be assigned to a single erosion feature).

Drainage Feature Problem	**Sloughing**		**Mass Failure**		**Gullying**		**Rilling**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Angle	0	0	0	0	0	0	2	1
Cover	0	0	0	0	7	12	5	3
Flow	0	0	0	0	2	4	0	0
Location Inappropriate	0	0	0	0	11	19	28	17
Spacing	0	0	0	0	26	46	92	56
Divert	0	0	0	0	5	9	19	12
Runoff Escaped	0	0	0	0	0	0	1	1
Maintenance	0	0	0	0	3	5	7	4
Height	0	0	0	0	0	0	1	1
Traffic	0	0	0	0	2	3	5	3
Other	0	0	0	0	1	2	4	2
Totals	0	0	0	0	57	100	164	100

The percentage of inventoried skid trail erosion features related to current operations that had dry season evidence of sediment reaching the high or low flow channel of a watercourse is shown in Figure 10. The percentages of sediment delivering features for sloughing, mass failures, gullying, and rilling features are 0, 0, 13.0, and 3.8 percent, respectively. Sediment delivery data was not reported for 8.3 percent of the rilling features, 2.1 percent of the gullies, 14.3 percent of the mass failures, and 0 percent of the sloughing events. No sediment was transported to the channel from any of the sloughing features or mass failures, 87 percent of the gullies, and 96.2 percent of the rills. For gullies that delivered sediment, 83.3 percent delivered sediment to Class III watercourses. All of the sediment delivered to channels from skid trail rills went to Class III watercourses. The proportions of erosion features delivering sediment from skid trails are considerably lower than that reported from similar types of erosion features found on the road transects (Figure 9).

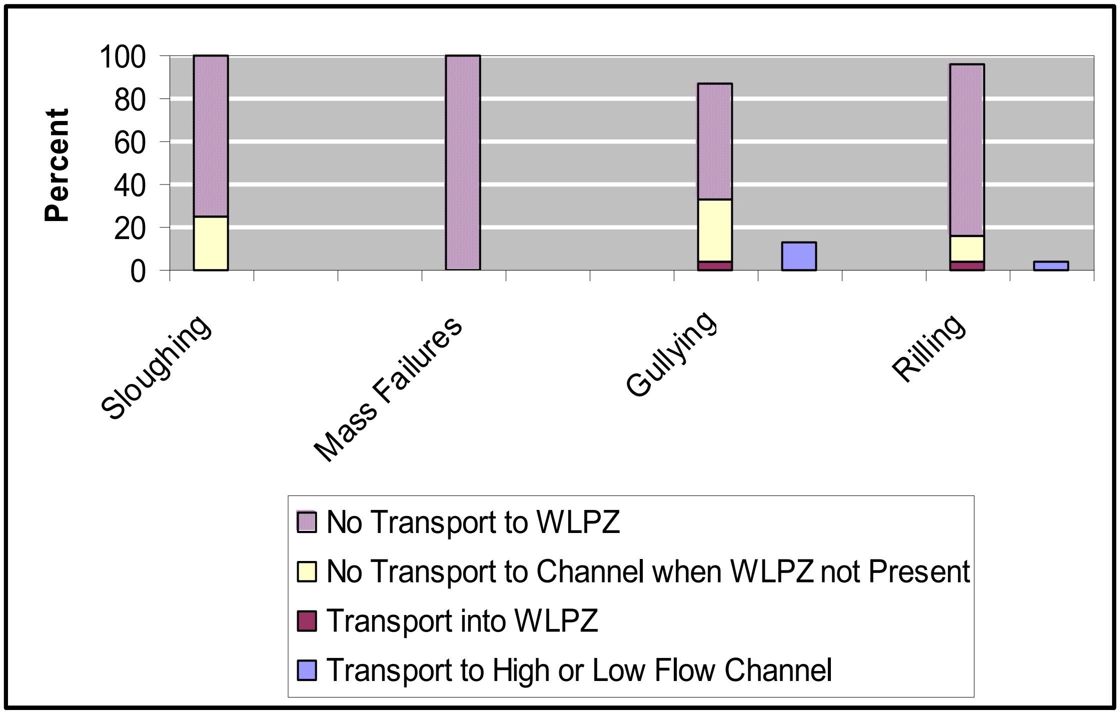

Figure 10. Percent of erosion features with dry season evidence of delivered sediment to the high or low flow channel of a watercourse from skid trail transect erosion features related to the current THP or NTMP NTO.

Landings

A total of 569 landings were evaluated from 1996 through 2001. Landing location and construction characteristics evaluated by the field team included: slope position, distance to the nearest watercourse, sideslope steepness, construction date, size, and fill dimensions. Landings were constructed on a ridge top, a “nose of a ridge”, or above a break in slope about 85 percent of the time (Figure 11). Approximately 52 percent of the landings were more than 300 feet from the nearest watercourse receiving drainage off the landing, 31 percent were 100 to 300 feet away, 10 percent were from 50 to 100 feet, and seven percent were less than 50 feet from the nearest watercourse. Two percent of the landings were constructed on slopes greater than 65 percent, seven percent of the landings were on slopes from 46 to 65 percent, 35 percent of the landings were on slopes from 31 to 45 percent, and 56 percent of the landings were on slopes from 0 to 30 percent. Approximately 69 percent of the landings monitored were existing landings built prior to the current plan; 31 percent of the landings were classified as new features. About 88 percent of the landings were less than or equal to ¼ acre in size (Figure 12). Approximately 69 percent of the landings had a maximum fill thickness of 0 to five feet, 24 percent had a maximum thickness of six to 10 feet, and seven percent had a maximum thickness of greater than 10 feet.

Implementation and effectiveness of applicable Forest Practice Rules were rated both at problem points and for the whole landing for 23 separate requirements based on 20 FPR sections. Overall implementation related to landings was rated following complete inspection of the landing and its cut slope and fill slope areas. In the overall evaluation, the Rules were met or exceeded **93.5** percent of the time. For Rule requirements with at least 30 observations, four were found to have more than five percent major and minor departures (Table 22). The Rule with the highest percentage of major departures and total departures was 14 CCR 923.1(a) [943.1(a), 963.1(a)], which requires an RPF to map landings greater than ¼ acre in size or those requiring substantial excavation. A major departure from the Rule requiring treatment of fill material when it has access to a watercourse was assigned to four percent of the landings, and ten percent were judged to have either a minor or major departure from the Rule requiring adequate numbers of drainage features.

As with the road and skid trail transect evaluations, the field team rated the implementation and effectiveness of landing related Rules at specific problem points (Table 23). A total of 106 problem points were recorded under the general categories of landing surface, landing surface drainage, landing cut slopes, and landing fill slopes. About 89 percent of the landings had no problem points assigned. On the remaining 11 percent, approximately one-third of the problem points were related to rills or gullies that were formed from concentrated runoff below the outlet of a drainage structure on the surface of the landing. Problem points are fairly evenly distributed among the remaining 10 sources displayed in Table 23, but the sum of fill slope erosion problems is nearly as large the number of problems related to concentrated runoff from surface drainage structures.

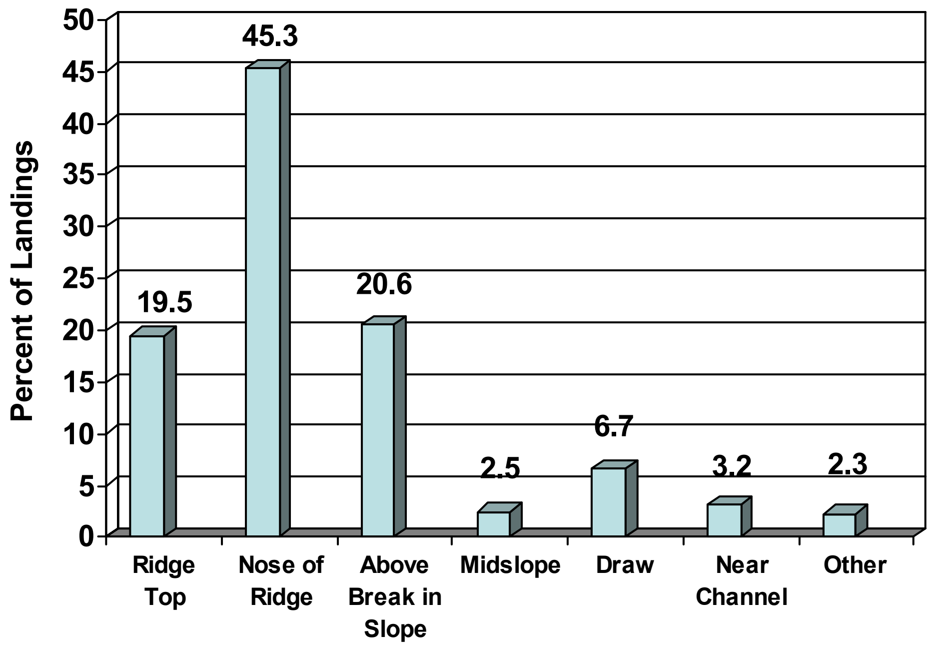

Figure 11. Distribution of landing geomorphic locations.

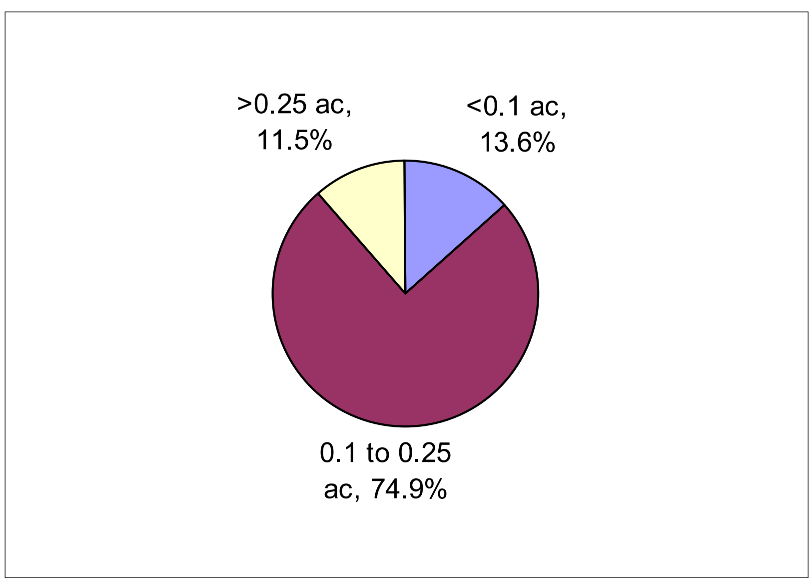

Figure 12. Landing size.

Table 22. Landing related Forest Practice Rule requirements with more than five percent total departures based on at least 30 observations from the overall evaluation where implementation could be rated (note that some of the Rule sections are separated into components and the table is ordered by the percentage of total departures).

Forest Practice Rule	Description	Total Number	% Total Departure	% Minor Departure	% Major Departure
923.1(a)	landings greater than 1/4 acre or requiring substantial excavation--shown on THP map	220	17.3	6.4	10.9
923.5(f)(4)	fill extending 20 feet with access to watercourse--treated	93	11.8	7.5	4.3
923.1(f)	adequate numbers of drainage structures	549	10.0	8.0	2.0
923.6	wet spots rocked or treated	154	5.8	5.8	0.0

At each problem point, the Forest Practice Rule(s) associated with that problem was rated for implementation (Table 24). Only 14 CCR 923.1(f) [943.1(f), 963.1(f)], which requires adequate numbers of drainage structures on landings to minimize erosion on landing surfaces, sidecast, and fills, was cited frequently. All of the problem points found on landings were judged to be caused by either minor or major departures from specific Forest Practice Rule requirements.

An overall effectiveness rating for each of the potential problem types listed in Table 23 was also completed for each landing. The complete summary of the landing effectiveness questions is displayed in Table A-1 in the Appendix. About 2.5 percent of the landings monitored had significant gullying on the landing surface. Of the landings with fill slopes (approximately two/thirds of the landings evaluated), about eight percent had gullies on the fill slopes and roughly three percent had slope failures that transported more than one cubic yard of material. For the landings with cut slopes (approximately 52 percent of the landings evaluated), roughly two percent had gullies on the cut slopes and about seven percent had slope failures with more than one cubic yard of material transported.

The landing evaluation also included a determination of the final location of sediment deposition originating from landing surfaces and fill slopes (Figure 13). Erosion features from two percent of the fill slopes produced sediment that entered channels, and another four percent of the time it reached the WLPZ. Similarly, erosion features from two percent of the drainage structures on the landing surfaces produced sediment that entered watercourses, and another six percent of the time it reached the WLPZ.[19]

Table 23. Distribution of problem points recorded at landings. Note that one landing can have multiple problem points.

Landing Area	Problem Type	Problem Count
Landing Surface	Rilling	8
	Gullying	9
Landing Surface Drainage	Erosion resulting from the drainage runoff structure or ditch	34
	Sediment movement from drainage structure	9
Landing Cut Slopes	Rilling	6
	Gullying	4
	Slope failures	5
Landing Fill Slopes	Rilling	8
	Gullying	8
	Slope failures	10
	Sediment movement to nearest channel	5
Total		106

Table 24. Problem point implementation ratings that account for 95 percent of all the Forest Practice Rule requirements rated at landings.

Forest Practice Rule	Description of Rules Rated for Implementation at Problem Points	Number of Times FPR Cited	Meets/ Exceeds Rule (%)	Minor Departure (%)	Major Departure (%)
923.1(f)	adequate numbers of drainage structures	63	0	76.2	23.8
923.5(f)(3)	landing sloped/ditched to prevent erosion	11	0	81.8	18.2
923.5(f)(2,4)	fill extending 20 feet with access to a watercourse--treated	9	0	33.3	66.7
923(g)	minimize cut/fill on unstable areas	6	0	0.0	100.0
923.1(d)	slopes greater than 65% or 50% within 100 feet-treated	6	0	50.0	50.0
923.5(f)(1)	slopes greater than 65% or 50% within 100 feet-treat edge	4	0	25.0	75.0
923.8	abandonment-minimize concentration of runoff	3	0	100.0	0.0

[19] Note that these ratings were only applied to landings where the appropriate features were present. For example, if no fill slopes were present, landing fill slope effectiveness questions were not answered. In total, 377 landings had fill slopes and 294 had cut slopes out of the 569 landings evaluated.

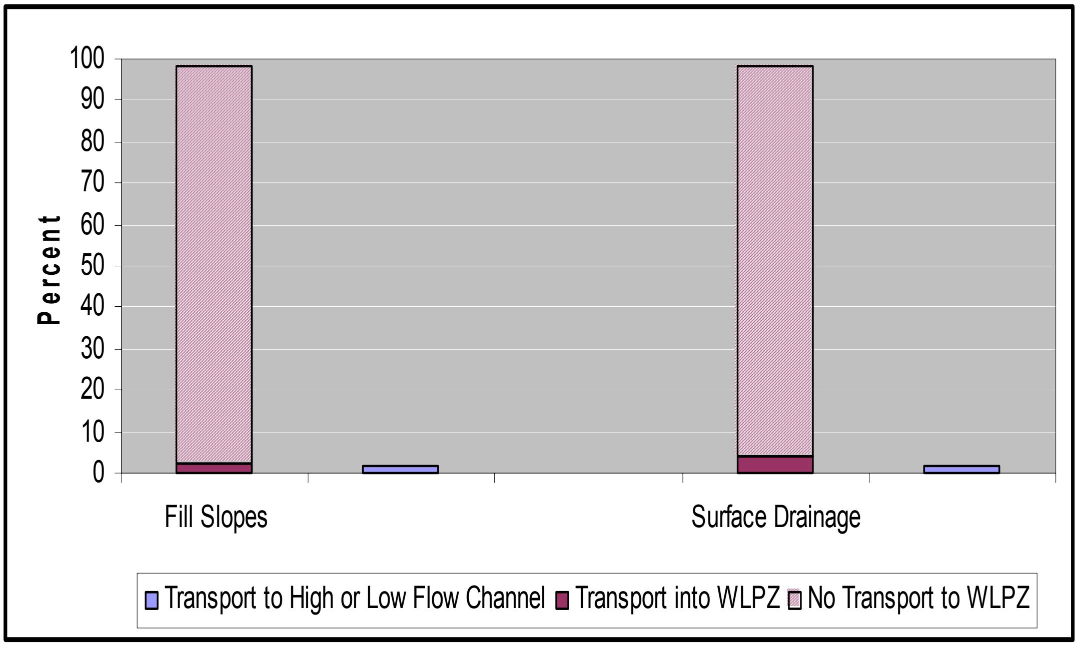

Figure 13. Percent of landing features related to the current THP or NTMP project that had dry season evidence of sediment delivered to either the WLPZ or the high/low flow channel of a watercourse.

Watercourse Crossings

A total of 491 watercourse crossings were evaluated from 1996 through 2001. Approximately 68 percent of these crossings had existing culverts (Figure 14), 12 percent were abandoned or removed road crossings, nine percent were fords, six percent were skid trail crossings, and two percent had bridges (Figure 15). The distribution of culvert sizes is displayed in Figure 16. The majority of pipe sizes are relatively small, reflecting the sampling criteria that favored choosing crossings located along road transects, which were often located above the break in slope near ridgelines. Approximately 64 percent of the crossings were existing road-related structures built prior to the beginning of the current plan; 18 percent were new road features; 12 percent were abandoned or removed crossings for roads; and six percent were removed, existing ford, or new skid trail crossings. Seventy-three percent of the crossings were associated with seasonal roads, 16 percent with permanent roads, four percent with temporary roads, six percent with skid trails, and less than one percent with abandoned roads. Forty-seven percent of the crossings were located in Class III watercourses, 46 percent in Class II drainages, six percent in Class I's, and less than one percent in Class IV watercourses.

Figure 14. Typical watercourse crossing sampled in the Hillslope Monitoring Program. This culvert was a crossing included in the sample for the 2002 field season.

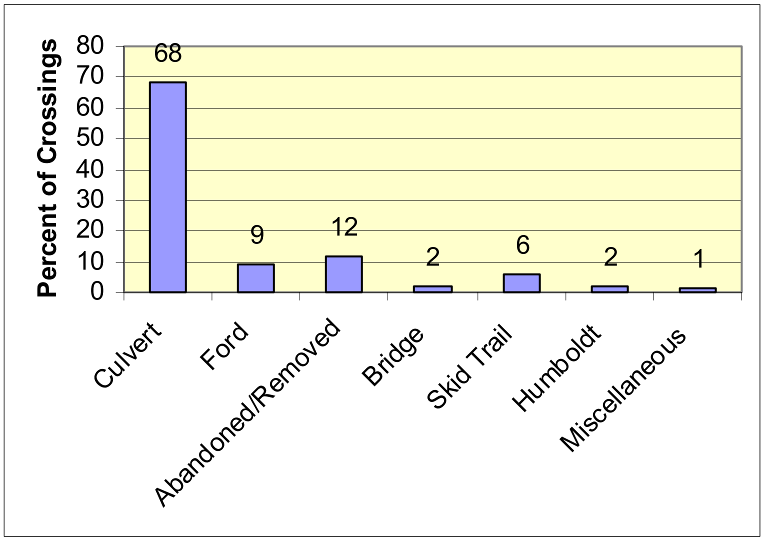

Figure 15. Distribution of watercourse crossing types evaluated from 1996 through 2001. The total number of crossings was 491.

Implementation and effectiveness of applicable Forest Practice Rules were rated both at problem points and for the whole crossing for 27 separate requirements from 24 Rule sections. Overall implementation of Rules related to watercourse crossings was rated following the complete inspection of the crossing, including the fill slope areas and the road segments draining to the crossing. In the overall evaluation, the Rules were met or exceeded **86.3** percent of the time. For Rule requirements with at least 30 observations, 21 were found to have more than five percent major and minor departures (Table 25). The Rules with the highest percentages of total departures were 14 CCR **923(o)** [943(o), 963(o)], **923.2(h)** [943.2(h), 963.2(h)], and **923.2(d)** [943.2(d), 963.2(d)], which prohibit discharge onto fill without appropriate energy dissipators; require appropriate size, numbers, and locations of structures to minimize erosion; and require fills across channels to be built to minimize erosion, respectively. Nine Rules had major departure percentages of more than five percent, which is substantially more than were found for the other hillslope areas (roads, skid trails, landings, and watercourse protection zones). Additional requirements with high levels of departures included Rules dealing with crossing diversion potential and proper crossing abandonment.

The field team rated the implementation and effectiveness of FPRs at problem points for specific components of watercourse crossings when they were encountered during the field inspection (Table 26). A total of 482 problem points were recorded under the general categories of crossing fill slopes, road surface drainage to the crossing, culverts, non-culverted crossings, removed or abandoned crossings, and road approaches at abandoned crossings. Problem points were identified on 45 percent of the crossings, indicating that deficient crossings often had more than one problem point. The most frequent problems were: culvert plugging, diversion potential, fill slope gullies, scour at the outlet of the culvert, ineffective road surface cutoff waterbreaks, and fill slope mass failures.

To determine if the high overall rate of crossing problems is coming from older crossings or continuing under current Rules, the database was queried to separate results from existing crossings, newly installed crossings, abandoned/removed road crossings, and skid trail crossings (Table 26). This revealed that the 88 new crossings had 68 total problem points, the 313 existing crossings (including culverts, fords, Humboldt crossings, and bridges) had 366 problem points, the 61 abandoned/removed road crossings had 43 problem points, and the 29 skid trail crossings had five problem points, which gives average values of 0.77, 1.17, 0.70, and 0.17 problem points per crossing for new, existing, abandoned/removed, and skid trail crossings, respectively.

A two-sample T test was used to test the difference between the means of the number of problem points for existing and new **culverted** crossings (the results are displayed in Table 27). This analysis revealed that the average of 0.77 problem points for new culvert crossings is significantly different (<0.01) than the average of 1.22 problem points at existing culverted crossings. However, problem points related to diversion potential, fill slope gullies, culvert plugging, and cut-off waterbreaks on roads draining to the crossing were still relatively common at new culvert crossings.

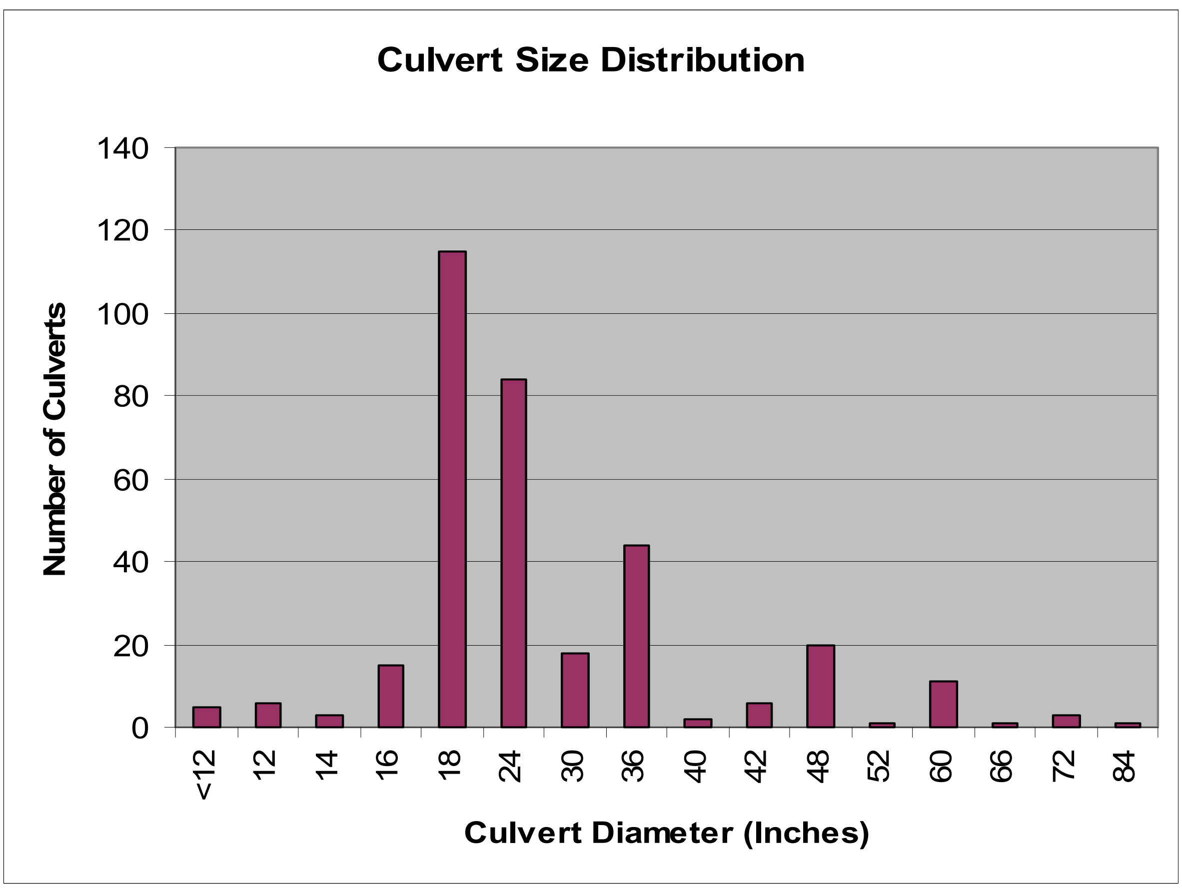

Figure 16. Culvert size distribution for watercourse crossings with pipes.

Table 25. Watercourse crossing related Forest Practice Rule requirements with more than five percent total departures based on at least 30 observations from the overall evaluation where implementation could be rated (note that some of the Rule sections are separated into components and the table is ordered by the percentage of total departures).

Forest Practice Rule	Description	Total Number	% Total Departure	% Minor Departure	% Major Departure
923.2(o)	no discharge on fill unless energy dissipators present	388	23.7	11.1	12.6
923.2(h)	size, number, and location of structures minimizes erosion	394	20.6	9.4	11.2
923.2(d) Coast	fills across channels built to minimize erosion	295	19.0	9.2	9.8
923.4(n)	crossing/approaches maintained to avoid diversion	403	16.6	12.7	4.0
923.4(1)	trash racks installed where there is abundant LWD	89	15.7	13.5	2.2
923.8	abandonment—minimize concentration of runoff	65	15.4	10.8	4.6
923.(c)	waterbreaks maintained to divert into cover	339	15.3	12.1	3.2
923.3(e)	crossing/fills built to prevent diversion	398	14.6	9.0	5.5
923.4(d)	crossing open to unrestricted passage of water	480	14.2	10.2	4.0
923.4(d)	trash racks installed where needed at inlets	78	14.1	10.3	3.8
923.8(d)	abandonment--pulling/shaping of fills	61	13.1	3.3	9.8
923.8(c)	abandonment--grading of road for dispersal	63	11.1	6.3	4.8
923.3(d)(2)	removed--cut bank sloped back to stop slumping	63	11.1	4.8	6.3
923.8(b)	abandonment--stabilization of exposed cuts/fills	63	11.1	6.3	4.8
923.3(d)(1)	removed--fills excavated to reform channel	64	10.9	7.8	3.1
923.2(h)	size, number, location of structures sufficient to carry runoff	394	10.7	3.6	7.1
923.8(e)	abandonment--fills excavated to reform channel	59	10.2	5.1	5.1
923.4	trash racks in place as specified in the THP	80	10.0	10.0	0.0
923.8(e)	abandonment--cutbanks sloped back	59	6.8	0.0	6.8
923.4(f)	50-year flood flow requirement	372	5.4	3.8	1.6
923.2(e)	throughfills built in one-foot lifts	39	5.1	2.6	2.6

Table 26. Distribution of problem points recorded for existing, new, abandoned, and skid trail watercourse crossings. Note that one crossing can have multiple problem points.

Crossing Feature	Problem Type	Existing Crossings (n = 313)	New Crossings (n = 88)	Road Abandoned/ Removed (n = 61)	Skid Trail Removed/ Ford (n = 29)	Totals
Fill Slopes	Vegetative cover	11	4	1	0	16
	Rilling	24	4	0	0	28
	Gullies	35	10	1	1	47
	Cracks	5	2	0	0	7
	Slope failure	28	4	2	0	34
Road Surface Draining to Crossing	Rutting	10	1	2	0	13
	Rilling	6	2	2	1	11
	Gullies	5	1	3	0	9
	Surfacing of approaches	5	2	2	1	10
	Cut-off waterbar	29	6	2	1	38
	Inside ditch condition	11	0	0	0	11
	Ponding	7	4	0	0	11
Culverts	Scour at inlet	5	0	NA	NA	5
	Scour at outlet	35	3	NA	NA	38
	Diversion potential	38	10	NA	NA	48
	Plugging	45	9	NA	NA	54
	Alignment	2	1	NA	NA	3
	Degree of corrosion	3	0	NA	NA	3
	Crushed inlet/outlet	8	0	NA	NA	8
	Pipe length	1	0	NA	NA	1
	Gradient	26	2	NA	NA	28
	Piping	10	1	NA	NA	11

Crossing Feature	Problem Type	Existing Crossings (n = 313)	New Crossings (n = 88)	Road Abandoned/ Removed (n = 61)	Skid Trail Removed/ Ford (n = 29)	Totals
Non-Culvert Crossings	Armoring	9	1	1	0	11
	Scour at outlet	5	1	1	0	7
	Diversion	3	0	0	1	4
Removed or Abandoned	Bank stabilization	NA	NA	5	0	5
	Rilling of banks	NA	NA	1	0	1
	Gullies	NA	NA	5	0	5
	Slope failure	NA	NA	2	0	2
	Channel configuration	NA	NA	5	0	5
	Excavated material and cutbank	NA	NA	3	0	3
	Grading and shaping	NA	NA	3	0	3
Road Approaches at Abandoned Crossings	Grading and shaping of road surface	NA	NA	2	0	2
Totals		**366**	**68**	**43**	**5**	**482**

Table 27. Distribution of watercourse crossing types and average numbers of problem points assigned for each crossing type.

Crossing Type	Number of Crossings	Number of Problem Points	Average Number of Problem Points/ Crossing
Existing Culvert	251	306	1.22*
New Culvert	83	64	0.77*
Existing Ford	40	39	0.98
New Ford	4	4	1.00
Abandoned/Removed (road)	61	43	0.70
Abandoned/Removed (skid trail)	19	1	0.05
Existing Skid Trail (ford)	8	4	0.50
New Skid Trail (ford)	2	0	0
Existing Humboldt	7	17	2.43
New Humboldt	1	0	0
Existing Bridge	11	0	0
Existing Rolling Dip	2	1	0.5
Other	2	3	1.50
Totals	**491**	**482**	**0.98**

* A two-sample T test comparing the number of problem points at existing versus new culverted crossings revealed that the means of these groups are significantly different at alpha < 0.01.

As with the other hillslope monitoring area categories, when a problem point was discovered, the field team rated the implementation and effectiveness of applicable Forest Practice Rule(s) associated with that problem (Table 28). Problems at crossings were associated with poor implementation of 24 Rule requirements, with 15 being cited as responsible for 95 percent of the problem points. All of the problem points were caused by either minor or major departures from specific Rule requirements. Overall, approximately 51 percent of the implementation ratings at the crossing problem points were recorded as minor Rule departures, while 49 percent were rated as major departures.

An overall effectiveness rating for each of the potential problem types listed in Table 26 was also completed for each crossing. A complete summary of watercourse crossing effectiveness questions is displayed in Table A-2 in the Appendix. Significant scour at the outlet of culvert crossings was found 33 percent of the time, with some degree of plugging occurring 24 percent of the time. Some level of diversion potential was noted for about 27 percent of the culverted crossings. Approximately 11 percent of the fill slopes at crossings had some amount of slope failure present. The road surface drainage cutoff structure above the crossing allowed all or some of the water running down the road to reach the crossing at about 23 percent of the sample sites. For abandoned or removed crossings, approximately 82 percent had channels established close to natural grade and orientation, with about 18 percent having minor or major differences.

Sediment delivery to watercourses is assumed to be 100 percent at crossings since these structures are built directly in and adjacent to the channels. Therefore, the evaluation of sediment delivery from the various types of problems associated with crossings was not conducted.

Table 28. Problem point implementation ratings that account for 95 percent of all the Forest Practice Rule requirements rated at watercourse crossings.

Forest Practice Rule	Description of Rules Rated for Implementation at Problem Points	Number of Times FPR Cited	Meets/ Exceeds Rule (%)	Minor Departure (%)	Major Departure (%)
923.2(h)	size, number, and location of structures minimizes erosion	126	0	43.7	56.3
923.2(o)	no discharge on fill unless energy dissipators installed	118	0	39.8	60.2
923.4(n)	crossing/approaches maintained to avoid diversion	71	0	77.5	22.5
923.2(h)	size, number, and location of structures sufficient to carry runoff	68	0	44.1	55.9
923.2(d) Coast	fills across channels built to minimize erosion	67	0	29.9	70.1
923.3(e)	crossing/fills built to prevent diversion	58	0	51.7	48.3
923.4(d)	crossing open to unrestricted passage of water	55	0	69.1	30.9
923.4(c)	waterbreaks maintained to divert into cover	43	0	74.4	25.6
923.8	abandonment—minimizes concentration of runoff	16	0	56.3	43.8
923.2(h)	size, number, and location of structures-maintains natural drainage pattern	15	0	73.3	26.7
923.8(d)	abandonment--pulling/shaping of fills appropriate	11	0	27.3	72.7
923.3(d)(2)	removed crossings--cut bank sloped back to prevent slumping and to minimize erosion	10	0	40.0	60.0
923.8(c)	abandonment--grading of road for dispersal	9	0	55.6	44.4
923.8(b)	abandonment--stabilization of exposed cuts/fills	9	0	55.6	44.4
923.3(d)(1)	removed crossings--fills excavated to reform channel	7	0	71.4	28.6

Watercourse Protection Zones (WLPZs, ELZs, EEZs)

From 1996 through 2001, 683 randomly located watercourse and lake protection zone (WLPZ) transects, equipment limitation zone (ELZ) transects, and equipment exclusion zone (EEZ) transects were evaluated, covering a total of approximately 510,800 feet or 96.8 miles for all three categories. The distribution of transects for each watercourse class is displayed in Figure 17. Approximately 17 percent of the WLPZs were associated with Class I watercourses (21.5 miles), 56 percent with Class IIs (64.4 miles), 27 percent with Class IIIs (10.4 miles), and less than one percent with Class IV waters (0.5 miles). Class III watercourses were not sampled as part of the Hillslope Monitoring Program from 1996 through 1999, but were included in 2000 and 2001.[20] For about 36 percent of the watercourse protection zone transects, the slope distance from the channel bank to the nearest road was greater than 150 feet; 18 percent had a distance of 100 to 150 feet; 25 percent had a distance of 50 to 100 feet, and 21 percent had a distance of less than 50 feet. The type of yarding upslope from the transect was classified as tractor 69 percent of the time, cable 22 percent, cable/tractor 6 percent, helicopter 2 percent, and tractor/helicopter less than 1 percent. Roads were located in 75 WLPZs, one equipment limitation zone (ELZ), and one equipment exclusion zone (EEZ).[21]

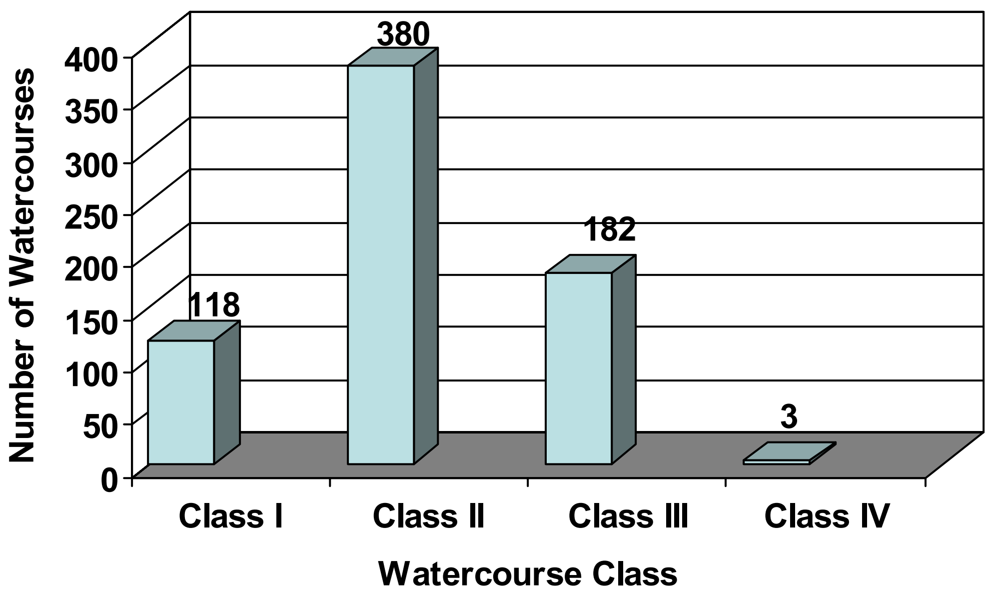

Figure 17. Distribution of watercourse classes evaluated from 1996 to 2001.

[20] Twelve Class III watercourses with WLPZs were evaluated in 1999 and 2 Class III watercourses with WLPZs were evaluated in 1997.

[21] WLPZs are not required for Class III watercourses. ELZs have been required for Class IIIs since January 1, 1998 (see 14 CCR 916.4(c)(1)). EEZs are often specified for these types of watercourses as well. ELZs allow heavy equipment in the zone only where explained in the THP and approved by the Director; EEZs are zones where heavy equipment is totally excluded.

As part of the WLPZ , ELZ, and EEZ transects, the field team rated the implementation and effectiveness of applicable Forest Practice Rules as they were encountered and as part of a subsequent overall evaluation following completion of the transect. A total of 56 questions were developed from 34 Rule sections and answered in the overall evaluation. When considering all the Forest Practice Rules related to watercourse protection zones, the implementation rate where the Rules were met or exceeded was **98.4** percent. The five Rule requirements with at least 30 observations and five percent or more major and minor departures are shown in Table 29. Three of these Rules relate to the requirement for the RPF to evaluate riparian areas for sensitive conditions, including the use of existing roads within the standard WLPZ and unstable and erodible watercourse banks. These factors are to be identified in the THP and considered when proposing WLPZ widths and protection measures. The other two Rules in Table 29 require that WLPZ widths must be at least equal to that specified in Table 1 (14 CCR 916.5 [936.5, 956.5]) in the Forest Practice Rules.

Very few erosion features associated with the current plan were found on the watercourse protection zone transects (Table 30). A total of 37 erosion features were recorded, with mass failures accounting for almost 50 percent. Most of the mass failures documented in the watercourse protection zones, however, were judged to either predate the current THP (127 features), were created after the THP but were not affected by the THP (17 features), or it was impossible to determine the feature date (17 features). The frequency of the erosion features associated with the current plan per mile of watercourse protection zone transect monitored is displayed in Table 31. Total erosion volumes for mass failures, sloughing, and gullying were approximately 2,900, 50, and 100 cubic yards, respectively. As was the case for the road and skid trail transects, these volume estimates are based on the dimensions of the voids remaining

Table 29. Watercourse protection zone (WLPZ, ELZ, and EEZ) related Forest Practice Rule requirements with more than five percent total departures based on at least 30 observations for the overall transect evaluation where implementation could be rated (note that some of the Rule sections are separated into components and the table is ordered by the percentage of total departures).

Forest Practice Rule	Description	Total Number	% Total Departure	% Minor Departure	% Major Departure
916.2(a)(4)	sensitive conditions--existing roads in WLPZ—appropriate mitigation measure(s) applied	133	9.0	4.5	4.5
916.4(a)	sensitive conditions--existing roads in WLPZ—identified in the THP	132	7.6	3.8	3.8
916.4(a)	sensitive conditions--erodible banks—identified in the THP	316	6.0	5.4	0.6
916.4(b)(3)	width of WLPZ conforms to Table 1 in the FPRs	593	5.6	4.7	0.8
916.4(b)	WLPZ widths as wide as specified in Table 1 in the FPRs	597	5.5	4.5	1.0

Table 30. Watercourse protection zone (WLPZ, ELZ, EEZ) transect erosion features associated with the current THP or NTMP NTO.

Erosion Feature	Number of Features 1996-1998	Number of Features 1999-2001	Total Number of Features 1996-2001
Cutbank/sidecast Sloughing	1	3	4
Mass Failure	13	5	18
Gullying	4	2	6
Rilling	5	4	9
Totals	23	14	37

on the hillslopes, not the amount of sediment delivered to watercourse channels. Also, similarly to what was reported for the road and skid transects, the number of erosion features for the various types of erosion were generally lower in the period 1999 through 2001 than from 1996 to 1998 (Table 30). Possible reasons for this difference are provided in the Discussion and Conclusions section of this report.

The percentage of watercourse protection zone transects that had one or more erosion features associated with the current plan of a given erosion type is shown in Table 32. Approximately 1.3 percent of the transects had at least one rill recorded, about 0.7 percent had one or more gullies, 2.0 percent had at least one mass failure, and 0.6 percent had sloughing present. These percentages are much lower than were found on roads and skid trails (see Tables 8 and 16).

When an erosion feature or other problem was found along the watercourse protection zone transects, implementation of the applicable Forest Practice Rule(s) was also rated for that problem point. A total of 27 Rule requirements were rated for implementation at watercourse protection zone problem sites. Of these, 20 Rules were associated with over 95 percent of the problem points (Table 33). When considering all the ratings

Table 31. Frequency of various types of erosion features associated with the current plan for the watercourse protection zone transects monitored.

Erosion Type	Class I (# features/mile)	Class II (# features/mile)	Class III (# features/mile)
Cutbank/Sidecast Sloughing	0	0.05	0.1
Mass Failure	0.4	0.2	0.2
Gullying	0.1	0.05	0.1
Rilling	0.1	0.1	0.1
Totals	0.6	0.4	0.5

Table 32. Percent of watercourse protection zone transects (all watercourse classes combined) with one or more erosion features associated with the current plan for selected types of erosion features.

Erosion Feature	Percent of Transects with One or More Features
Sloughing	0.6
Mass Failures	2.0
Gullying	0.7
Rilling	1.3

assigned at problem points encountered, about seven percent were associated with situations where the Rule requirements were found to have been met or exceeded and roughly 93 percent of the problem points were associated with minor or major departures from Rule requirements. The most commonly cited Rules rated for implementation at problem points were: 1) an inappropriate WLPZ width, 2) trees were not felled away from the watercourse channel, and 3) heavy equipment was not excluded from the watercourse protection zone and the approved THP did not permit this activity.

Canopy cover was measured with the spherical densiometer from 1996 through 1998 (Figure 18) and the sighting tube from 1999 through 2001. Mean total canopy cover measurements are displayed in Table 34. In all cases, average post-harvest values were above 70 percent. Average canopy values were also determined for each of the three CDF Forest Practice Districts for the sighting tube data (Figure 19). Mean values were highest in the Coast Forest Practice District (approximately 80 percent for both Class I and IIs) and lower in the interior districts. Lower values inland are probably related to warmer, drier conditions and the presence of slower growing tree species. In all cases, mean total canopy levels exceeded the Forest Practice Rule requirements in place for Class II watercourses. This is likely true for Class I watercourses as well, but overstory and understory canopy were not differentiated in this project as described by the Rules.[22]

Surface (or ground) cover was evaluated at 100 foot intervals along the watercourse protection zone transects for Class I, II, and III watercourses (Table 35). In all cases, surface cover exceeded the post-harvest Rule standard of 75 percent. Surface cover was generally similar for the three different Forest Practice Districts. Southern District Class I surface cover was slightly lower than that found in the other two districts. In the Coast Forest Practice District, high precipitation and summer fog near the ocean promote an environment that is quickly covered with surface vegetation. In the drier

[22] Since pre-harvest canopy measurements were not made at the THP and NTMP project sites, it is not possible to state what the change in canopy was due to timber harvesting activities associated with the current plan.

inland districts, bare soil is common in some locations even prior to logging. For all three districts, Class II and III surface cover means were higher than that for Class I watercourses.

Table 33. Problem point implementation ratings that account for over 95 percent of all the Forest Practice Rule requirements rated along watercourse protection zone segments.

Forest Practice Rule	Description of Rules Rated for Implementation at Problem Points	Number of Times FPR Cited	Meets/ Exceeds Rule (%)	Minor Departure (%)	Major Departure (%)
916.4(b)(3)	width of WLPZ conforms to Table 1	43	0	62.8	37.2
916.4(b)	WLPZ widths as wide as specified in Table 1	42	0	59.5	40.5
916.3(e)	trees in WLPZ felled away from channel	25	4	60.0	36.0
916.4(d)	heavy equipment excluded from the zone unless explained and approved	13	0	46.2	53.8
916.5(e)"I"	Class II--50% of total canopy left in WLPZ	11	0	45.5	54.5
916.3(c)	roads, landings outside of WLPZs	10	0	30.0	70.0
916.5(b)	beneficial uses consistent with WLPZ classes	9	0	33.3	66.7
916.2(a)(4)	sensitive conditions--unstable banks--mitigation measure(s) applied	8	0	100.0	0.0
916.4(b)	THP provides for upslope stability	8	25	62.5	12.5
916.5(a)(3)	side slope classes used to determine WLPZ width and protective measures	7	0	71.4	28.6
916.4(b)	THP provides for protection of water temperature	7	28.6	42.9	28.6
916.2(a)(4)	sensitive conditions--existing roads in WLPZ-- mitigation measure(s) applied	6	0	16.7	83.3
916.3(g)	Class I/II--2 living conifers per acre 16 in. or greater DBH, 50 ft tall retained within 50 feet of the watercourse	6	16.7	66.7	16.7
916.4(a)	sensitive conditions--existing roads in WLPZ identified in the THP	6	0	33.3	66.7
916.4(b)	THP provides for channel stabilization	6	33.3	33.3	33.3
916.4(b)	THP provides for filtration of organic material	4	50	50.0	0.0
916.5(e)"G"	Class I--50% overstory and 50% understory retained	3	0	100.0	0.0
916.4(a)	sensitive conditions--erodible banks identified in the THP	3	0	100.0	0.0
916.4(b)(4)	WLPZ width segregated by slope class	3	0	100.0	0.0
916.4(c)(3)	Class III--soil removed or stabilized	3	0	66.7	33.3

Table 34. Mean WLPZ total canopy cover measurements.

Year/Location	Class I Canopy Cover (%)	Class II Canopy Cover (%)
1996—North Coast Spherical Densiometer	79	77
1997 to 1998—Statewide Spherical Densiometer	74	75
1999 to 2001—Statewide Sighting Tube	73	75

Figure 18. Measuring canopy cover with the spherical densiometer in western Mendocino County in 1996.

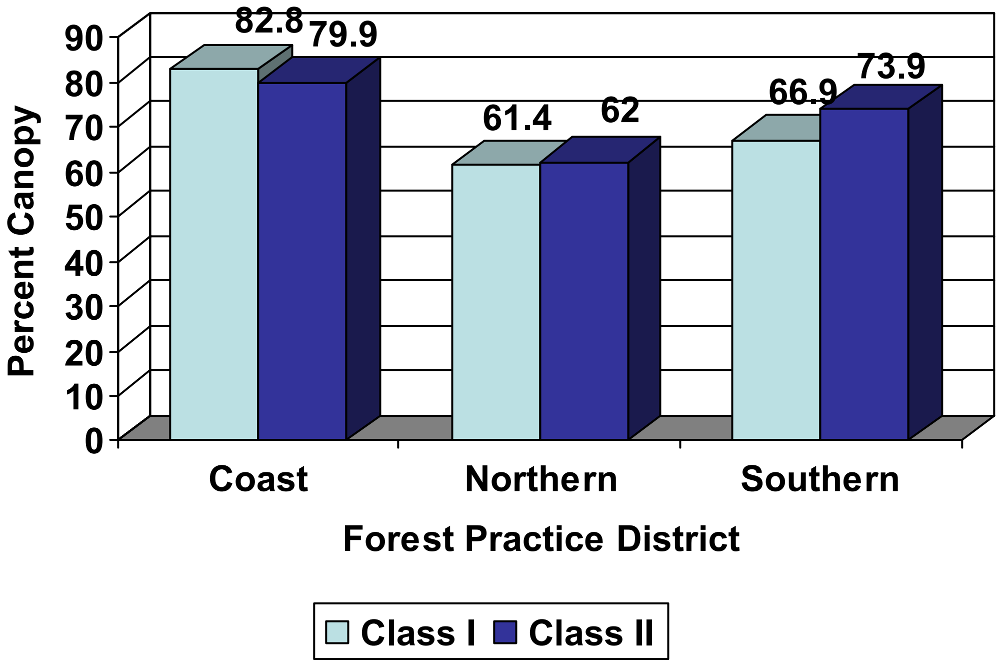

Figure 19. Total canopy cover percentages for Class I and II watercourses from 1999 through 2001 by Forest Practice District (data measured with a sighting tube).

Table 35. Mean surface cover values for the three CDF Forest Practice Districts.

CDF Forest Practice District	Class I Surface Cover (%)	Class II Surface Cover (%)	Class III Surface Cover (%)
Coast	82.5	97.1	98.3
Northern	81.9	95.3	93.0
Southern	76.2	95.4	97.6

Mean watercourse protection zone widths were estimated or measured as part of the transect effectiveness evaluation process. Mean widths for Forest Practice Rule side slope categories are shown in Table 36. It was often difficult for the field team to determine the upper extent of the WLPZ—particularly where selective silvicultural systems were used above the WLPZ. Flagging used to denote the WLPZ was often gone or difficult to locate following several overwintering periods, resulting in the estimation of WLPZ widths in some cases. It is also unknown exactly how many of the WLPZs sampled utilized the allowable reduction granted for cable yarding systems (50 foot reduction for Class I and 25 foot reduction for Class II watercoures). Thirty percent of the WLPZ transects had cable or helicopter yarding upslope of the transect (this includes areas that were listed as both cable and tractor). As reported above (Table 29), WLPZ width problems were only cited on about six percent of the transects, and major departures for the overall evaluation were only recorded for one percent of the transects.

The percentage of inventoried watercourse protection zone erosion features related to current operations that had dry season evidence of sediment reaching the high or low flow channel of a watercourse is shown in Figure 20. The percentages of sediment delivering features for sloughing, mass failures, gullying, and rilling features are 66.7, 64.3, 83.3, and 88.9 percent, respectively. No sediment was transported to the channel for 33.3 percent of the sloughing features, 35.7 percent of the mass failures, 16.7 percent of the gullies, and 11.1 percent of the rills. Of the rills that delivered sediment to watercourses, 12.5 percent delivered to Class III watercourses. For gullies that delivered sediment, 20 percent input sediment to Class III watercourses. Sediment delivery data was not reported for 0 percent of the rilling features, 0 percent of the gullies, 22.2 percent of the mass failures, and 25 percent of the sloughing events. The proportions of erosion features delivering sediment in watercourse protection zones are considerably higher than that reported from similar types of erosion features found on the road and skid trail transects (Figures 9 and 10), due to the close proximity of these features to the channel.

Table 36. Mean WLPZ width estimates.

Watercourse Class	Side Slope Gradient Category (%)	Mean WLPZ Width (feet)	Standard Forest Practice Rule Width (feet)
I	<30	79	75
	30 to 50	96	100
	$\geq$50	119	150[23]
II	<30	53	50
	30 to 50	72	75
	$\geq$50	90	100[12]

[23] 50 foot and 25 foot reductions in WLPZ width are allowed with cable yarding for Class I and II watercourses, respectively (see Table 1, 14 CCR 916.5 [936.5, 956.5]).

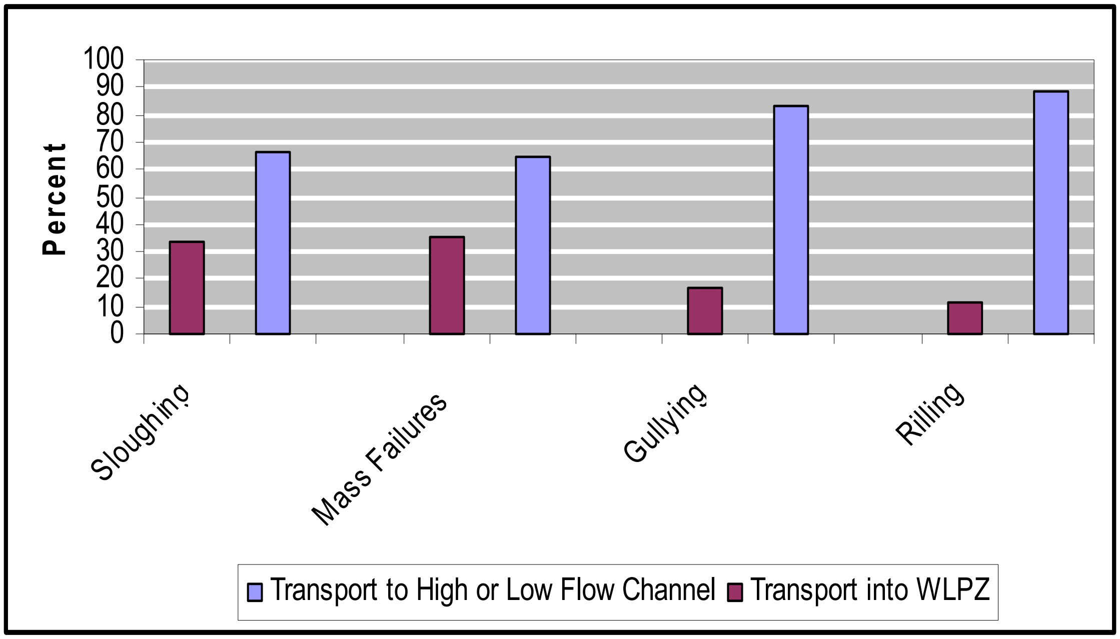

Figure 20. Percent of erosion features with dry season evidence of delivered sediment to the high or low flow channel of a watercourse from watercourse protection zone transect features associated with the current THP or NTMP project.

Large Erosion Events

While the sampling approach for roads, skid trails, landings, watercourse crossings, and watercourse protection zones utilized a very detailed evaluation for a small portion of a THP or NTMP Project, the inventory of large erosion events and associated site and management factors covered a significant portion of the THP or NTMP Project area as a whole. This more extensive approach was used in an attempt to determine the impacts of large erosion events, which may be responsible for a majority of hillslope erosion while occurring on a very limited portion of the landscape that a randomized sample approach is likely to miss. This is particularly important where mass wasting is the dominant erosional process (Rice and Lewis 1991, Lewis and Rice 1989, Lee 1997).

Erosion sites with: 1) 100 cubic yards or more on hillslopes, and 2) 10 cubic yards or more at failed watercourse crossings, were documented wherever they were found. Large erosion events were identified primarily when traveling within the THP, either by foot or in a vehicle, as part of the evaluations for randomly located road segments, skid trail segments, landings, crossings, and watercourse protection zones. Additional large erosion events were identified from THP maps. Recorded information included the size and type of erosional feature, site conditions, and specific timber operations. Where specific Forest Practice Rules could be connected to a feature, they were recorded as well. These types of evaluations were completed only for the statewide hillslope monitoring work (1997 through 2001).[24]

In-unit mass wasting was not included in this inventory because surveys of logging unit(s) were not required in the other components of the Hillslope Monitoring Program. Therefore, the impacts of the Forest Practice Rules on in-unit mass wasting, other than those large erosion events primarily triggered by the roads, skid trails, watercourse crossings, and landings evaluated within the plan, were largely undetermined (Stillwater Sciences 2002).[25]

A total of 50 large erosion events were located on the 250 THPs and NTMP projects included in this portion of the Hillslope Monitoring Program. These events were found on 37 THPs, or 15 percent, with nine plans having multiple features. Of the 50 total

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[24] The 1996 large erosion event monitoring in Humboldt and Mendocino Counties was considered a pilot project to further refine how the data would be collected. The initial procedure used in 1996 is described in Tuttle (1995). The process was modified significantly based on information provided by the Hillslope Monitoring Program contractors who completed the field work in Mendocino and Humboldt Counties during 1996.

[25] Additional information on this subject can be found for Humboldt County watersheds in PWA (1998a, 1998b) and Marshall (2002), Mendocino County in Cafferata and Spittler (1998), and Northern California in general as part of the Critical Sites Erosion Study (Durgin et al. 1989, Lewis and Rice 1989, Rice and Lewis 1991). Also, the California Geological Survey has preliminary data on frequency of mass wasting events in clearcut units and adjacent uncut units in Jackson Demonstration State Forest, located near Fort Bragg, California (contact Mr. Thomas Spittler, CGS, Santa Rosa, CA). Information on mass wasting related to forestry operations in Oregon is available in Robison et al. (1999).

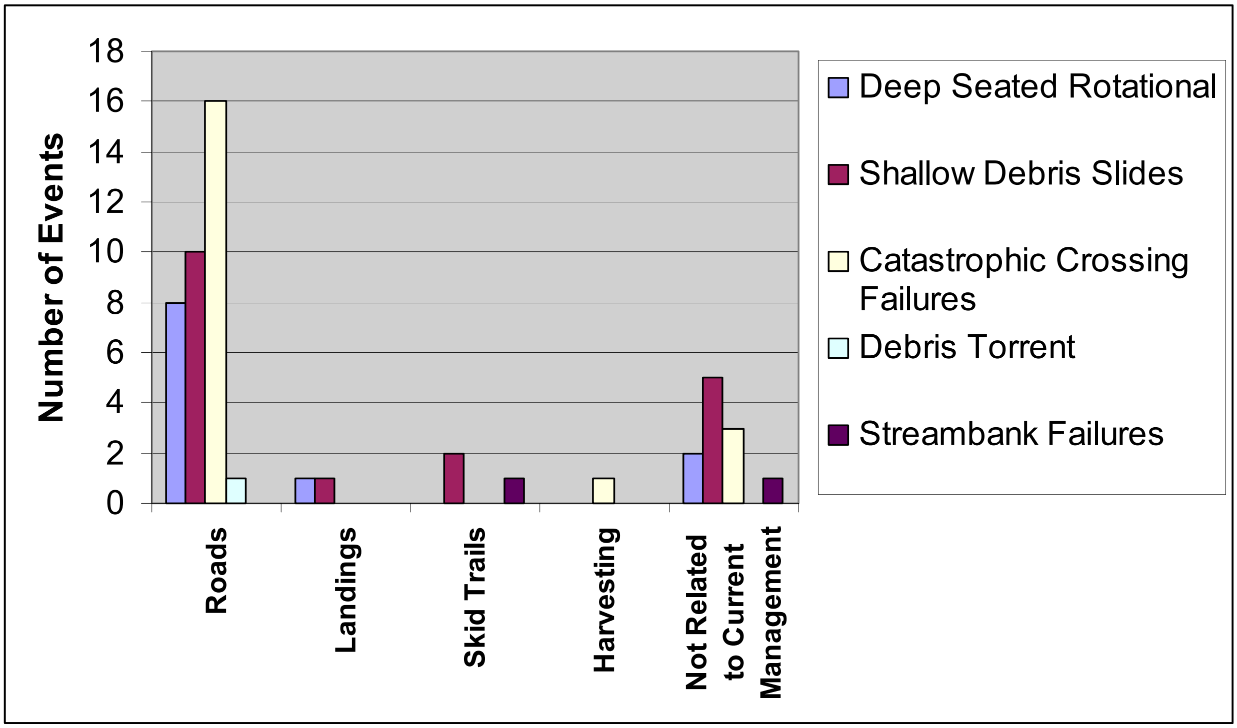

Figure 21. Primary causes of large erosion events and type of feature (note that multiple causes were assigned in some instances).

features, 39 were classified as being related to current timber management activities (Figure 21).

As shown in Table 37, nearly all of the shallow debris slide features were found in the Coast Forest Practice District, as were the majority of the deep seated rotational features. Since there were 4.7 and 2.3 times more THPs and NTMP projects in the Coast Forest Practice District when compared to the Southern and Northern Districts (Table 1), respectively, the actual frequency of catastrophic crossing failures is much higher in the inland districts. This can be partly explained by the very large rain-on-snow event which occurred in January 1997, which was at least a 100-year recurrence interval runoff event in many parts of the Sierra Nevada Mountains. Streambank failures related to the current plan and debris torrents were recorded infrequently. As with the numbers of erosion features recorded on road, skid trail, and watercourse protection zone transects, the numbers of large erosion events were considerably lower in period from 1999 through 2001 (15 features) than during the 1997-1998 period (35 features) (Figure 22).

Average volumes for the various types of erosion features related to current management activities in all three Forest Practice Districts were as follows: deep seated rotational failures—19,800 cubic yards, shallow debris slide features—3,500 cubic yards, catastrophic crossing failure features—65 cubic yards, streambank failures—600 cubic yards, and debris torrent features—550 cubic yards.

Table 37. Frequency distribution of large erosion events that were encountered on THPs and NTMP projects evaluated from 1997 through 2001.

Type of Feature	Coast	Northern	Southern	Total
Deep seated rotational	7	3	1	11
Shallow debris slide	14	3	0	17
Debris torrent	1	0	0	1
Streambank Failure	1	0	1	2
Catastrophic crossing failure	6	6	7	19
Totals	29	12	9	50

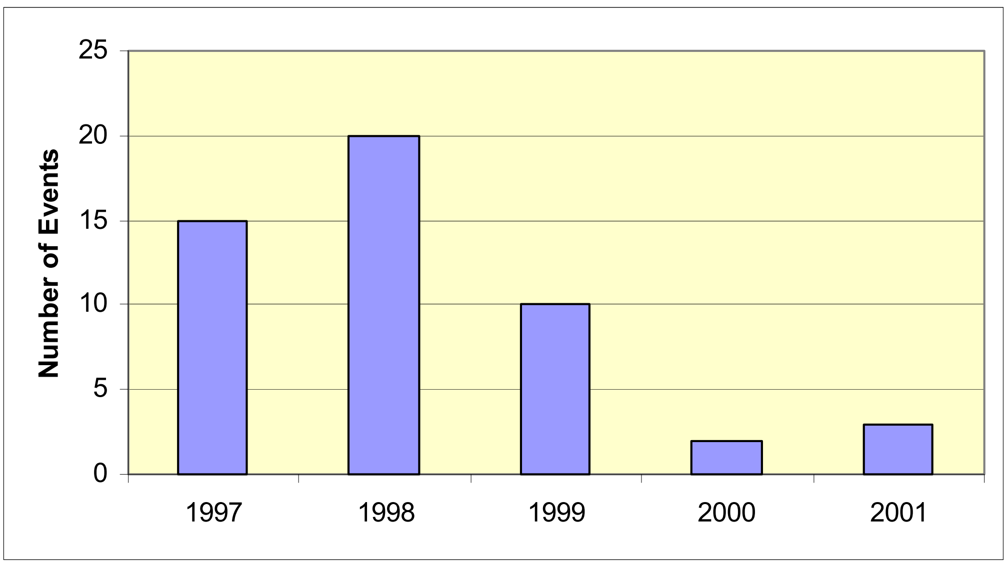

Figure 22. Year data was recorded on the large erosion events inventoried.

Most of the inventoried large erosion events related to management activities in the current plan were associated with roads (35), with smaller numbers of events associated with skid trails (3), landings (2), and harvesting (1). Cause codes and associated features are displayed in Figure 21, while specific cause codes are shown in Table 38 (multiple cause codes were assigned in some instances, so the total is greater than the 39 events). The most frequent causes of management related large erosion events were: cutbanks with slope support removed; subsurface water concentration;

culverts with plugged inlets; fill slopes with overloaded, deep sidecast; and culverts which were judged to be too small.

Table 38. Management related causes of inventoried large erosion events (note that multiple causes were often assigned to a single event).

Type of Feature	Cause of Feature	Count
Roads	Waterbars-discharge onto erodible material	3
	Waterbars-improperly constructed or located	3
	Fill slopes-too steep	3
	Fill slopes-overloaded, deep sidecast	6
	Fill slopes-poorly compacted	4
	Fill slopes-excessive organic material	1
	Culverts too small	5
	Culverts-discharge onto erodible material	2
	Culverts-inlet plugged	8
	Culverts-broken and leaking into the roadbed	1
	Inside ditch-ditch blocked and/or diverted	1
	Inside ditch-other drainage onto road not handled	4
	Cutbanks- too steep	3
	Cutbanks-slope support removed	11
	Subsurface flow alteration	1
	Cross drains-too small	1
	Cross drains-discharge onto erodible material	1
	Cross drains-improperly constructed or located	3
	Subsurface water concentrations-discharge onto erodible material	9
Skid Trails	Waterbars-not properly draining area	2
	Cutbanks-too steep	1
	Cutbanks-slope support removed	2
	Surface water concentration-rilling and gullying	1
	Surface water concentration-discharge on erodible material	2
Landings	Cutbanks-too steep	1
	Cutbanks-slope support removed	1
	Fill slopes-excessive organic material	1
	Waterbars-discharge onto erodible material	1
	Subsurface flow alteration	1
Harvesting	Alteration of natural drainage during yarding	1

Non-Standard Practices and Additional Mitigation Measures

Additional mitigation measures beyond the standard Rule requirements are often added to THPs. These mitigations may be the basis for acceptance and approval of proposed in-lieu or alternative practices and, ultimately, the THP. This summary should be considered an initial, first-phase review of non-standard practices (including in-lieu and alternative practices) and additional mitigation measures, from which future work can be built upon. Further evaluation of the implementation and effectiveness of these types of practices is needed.

A more complete evaluation approach was not developed during the Pilot Monitoring Program (1993-1995) due to the difficulty in addressing the variability of prescriptions developed for site specific problems (Lee 1997), but is needed for future monitoring work. The Hillslope Monitoring Program Interim Report (CSBOF 1999) did not address this topic, so this is the first time that these data have been summarized. It is important to note that site-specific practices and/or additional mitigation measures often did not apply at the randomly selected transects and features, so the totals reported below are a small sample that does not include all of the types of practices that were included in the THPs and NTMP projects. Additionally, the features were not examined to the same degree of rigor as on the randomly located transects evaluated for standard Rule compliance and at large erosion sites, and the narrative evaluations were based on requirements specified in the THP provided to the contractors, some of which may have been modified through amendments that were not reviewed.[26]

A brief summary of the qualitative responses provided for non-standard practice and additional mitigation measure implementation and effectiveness follows for each feature type.

Roads

Of the 568 road transects evaluated in the field, a total of 45 transects had entries in the Hillslope Monitoring Program database for the implementation and effectiveness of non-standard practices or additional mitigation measures. The most commonly approved non-standard practice was the use of roads in WLPZs,[27] followed by roads on steep slopes (greater than 65 percent). Frequently prescribed additional mitigation measures were: 1) seeding and mulching or rocking road surfaces and 2) decreasing the distance between waterbreaks (to high or extreme erosion hazard rating standards). As shown in Table 39, about 15 percent of these sites had existing or potential problems, of which four percent was associated with lack of implementation and nine percent with

[26] The field team was not always supplied with a complete set of the reviewing agencies' Pre-Harvest Inspection reports and Amendments to the THP.

[27] Currently, construction or reconstruction of a road within a WLPZ is an in-lieu practice (14 CCR 916.3(c) [936.3(c), 956.3(c)], except at new crossings approved as part of the Fish and Game Code process. Use of existing roads in WLPZs is addressed in 14 CCR 916.4(a) [936.4(a), 956.4(a)], but is not considered an in-lieu practice.

acceptable implementation. Overall, the specified practices were not fully implemented at about 13 percent of the applicable sites, and approximately 70 percent were judged to be properly implemented and effective. For approximately three percent of the applicable sites, full implementation of the specified measures was lacking but effectiveness was judged to be acceptable.

Skid Trails

Non-standard practices or additional mitigation measures were evaluated at thirty-seven of the 480 skid trail transects completed for this project. The most common practices included: 1) more frequent waterbreak spacing than required by the standard Rules, 2) tractor operations on slopes steeper than permitted by the standard FPRs, and 3) use of existing skid trails in watercourse protection zones. As shown in Table 40, only four of these practices (9 percent) were described as having existing or potential problems, of which three were associated with poor implementation and one with acceptable implementation. The specified practices were not fully implemented on approximately 25 percent of the applicable sites and were judged to be properly implemented and effective about 60 percent of the time.

Landings

A total of 28 landings had entries for non-standard practices or additional mitigation measures, out of a possible 569 features. Nearly all of these were alternatives with approval for use of WLPZ landings, usually in conjunction with additional mitigation measures that generally specified the use of seeding and mulching or rocking. As shown in Table 41, about seven percent of the sites where these practices and measures were applied had existing or potential problems, all of which were associated with acceptable implementation. About four percent of the practices were not fully implemented and almost 90 percent were properly implemented and effective.

Watercourse Crossings

Of the 491 watercourse crossings evaluated, non-standard practices or additional mitigation measures were evaluated at 18 sites as part of the hillslope monitoring process. Common mitigation measures applied at these sites included: mulching and seeding fill slopes or abandoned crossings, and use of rock for inlet or road approaches. As shown in Table 42, three of the practices at these 18 crossings (about 11 percent) had existing or potential problems, of which all were associated with acceptable implementation. Approximately 15 percent of the practices were not fully implemented. Fifty-six percent of the practices evaluated were judged to be properly implemented and effective.

Watercourse Protection Zones (WLPZs, ELZs, and EEZs)

Of the 683 watercourse protection zones transects evaluated in the field, 56 transects had entries in the Hillslope Monitoring Program database for the implementation and effectiveness of non-standard practices or additional mitigation measures. Commonly specified practices and mitigation measures were: 1) use of existing roads within WLPZs, 2) use of existing skid trails in the WLPZ , 3) no-cut WLPZs, 4) additional canopy retention requirements in the WLPZ over the standard Rule, and 5) wider WLPZs than required by the standard Rule. When evaluating the frequent practice of using existing WLPZ roads, the field team often stated that there was no *apparent* sediment delivery to the watercourse channel. It is important to recognize that these inspections were completed in the dry summer and fall months, when observation of possible fine sediment transport during winter storm events was not possible.

Table 43 displays the implementation and effectiveness ratings for the non-standard practices and additional mitigation measures for watercourse protection zones. About eight percent of these practices and measures were applied had existing or potential problems, of which one percent was associated with poor implementation and seven percent with acceptable implementation. Approximately five percent of the practices were not fully implemented. Seventy-four percent of the practices were properly implemented and effective (see the comments about fine sediment transport above).

Table 39. Summary of recorded non-standard practices and additional mitigation measures for roads.

Non-Standard Practice	Count	I/E	I/P	I/UE	UI/E	UI/P	NI/E	NI/P	NI/U
Use of WLPZ road	20	17	2		1				
No harvesting between road and stream	1	1							
Extreme EHR waterbar spacing	2	1					1		
High EHR waterbar spacing with 12 inch waterbars	1	1							
High erosion hazard rating for waterbar spacing	4			1				1	2
Use of reduced waterbar spacing	2	1	1						
Place hay bale at WLPZ waterbar outlets	1	1							
Seed and mulch road surface	4	4							
Straw mulch on road	3	3							
Road rocking	6	6							
Rock crossing approaches	1		1						
Rock Class III crossings	1	1							
Road on >65% slopes	3	3							
Roads on >65% slope and road segment >15% grade	1	1							
Full bench road construction	2	2							
Full bench road construction on unstable slopes<65%	1							1	
Outslope roads	2			1			1		
Endhauling	1	1							
Place fill in safe location	2			1					1
Push excess material to slopes <40%	1	1							
No sidecast	2	2							
No deposition from clearing cutbanks and/or brow log	1								1
Remove overhanging banks	1			1					
Reconstruct roads in wet areas	1	1							
Road moved and new crossing installed	1	1							
Class III off of road/improve drainage through landing	1	1							
Road abandonment	1								1
Remove culvert	1					1			
Winter hauling limited to firm road surface	1		1						
No winter hauling when sediment can reach stream	2		2						
Dip out crossing and mulch	1	1							
Use of excavator	1	1							
Whole tree yarding from road	1			1					
Block road	2	1						1	
Totals	76	52	7	5	1	1	2	3	5
Percent	100	68.4	9.2	6.6	1.3	1.3	2.6	4	6.6

"I/E" = Implemented and Effective/No Problem Observed
"I/P" = Implemented and Problem or Potential Problem Exists
"I/UE" = Implemented and Unknown Effectiveness
"UI/E" = Unknown Implementation and Effective/No Problem Observed
"UI/P" = Unknown Implementation and Problem or Potential Problem Exists
"NI/E" = Not Implemented and Effective/No Problem Observed
"NI/P" = Not Implemented and Problem or Potential Problem Exists
"NI/U" = Not Implemented and Unknown Effectiveness

Table 40. Summary of recorded non-standard practices and additional mitigation measures for skid trails.

Non-Standard Practice	Count	I/E	I/P	I/UE	UI/E	UI/P	NI/E	NI/P	NI/U
Use of WLPZ skid trail	4	2	1	1					
Use of WLPZ road for heavy equipment	1	1							
More frequent waterbar spacing than standard rule	2	1						1	
Waterbreak spacing at extreme EHR	7	4					1		2
Waterbreak spacing at high EHR	9	4					2	2	1
High EHR waterbar spacing with 12 inch waterbars	2			2					
Seed and mulch removed skid trail crossing	2	1		1					
Mulch approaches ot removed skid trail crossing	1	1							
Seed and mulch skid trails in WLPZ	2	1					1		
Seed and mulch skid trails on slopes >40%	1						1		
Seed and slash skid trails	1	1							
Slash and mulch skid trails	1	1							
Chip and slash skid trails	1	1							
Use of existing skid trails on slopes >65%	4	4							
Use of tractors in cable area	1	1							
Use of existing skid trails without watercourse crossings	2	2							
Skid trail crossing of Class II watercourse	1			1					
Tractor yarding during dry conditiong in winter period	1	1							
Tractor crossing of Class IV watercourse	1			1					
Totals	44	26	1	6	0	0	5	3	3
Percent	100	59.1	2.3	13.6	0	0	11.4	6.8	6.8

"I/E" = Implemented and Effective/No Problem Observed
"I/P" = Implemented and Problem or Potential Problem Exists
"I/UE" = Implemented and Unknown Effectiveness
"UI/E" = Unknown Implementation and Effective/No Problem Observed
"UI/P" = Unknown Implementation and Problem or Potential Problem Exists
"NI/E" = Not Implemented and Effective/No Problem Observed
"NI/P" = Not Implemented and Problem or Potential Problem Exists
"NI/U" = Not Implemented and Unknown Effectiveness

Table 41. Summary of recorded non-standard practices and additional mitigation measures for landings.

Non-Standard Practice	Count	I/E	I/P	I/UE	UI/E	UI/P	NI/E	NI/P	NI/U
Use of WLPZ landing	17	15	2						
Use of ELZ landing	1	1							
Rock landing surface	4	4							
Seed and mulch landing surface	4	4							
Slash and mulch landing surface	2	2							
Inslope landing, mulch, install brow log	1	1							
Drain to avoid discharge on fillslope	1								1
Install ditch for drainage	1						1		
Outslope landing	2	2							
Seed and mulch, install brow log, hay bale	1	1							
Seed landing	2	2							
Mulch landing	3	3							
Install brow log on landing surface	2	1	1						
Landing >1/4 ac for helicopter yarding	1	1							
Helicopter landing in WLPZ	1	1							
Relocate landing away from Class III watercourse 50 feet	1	1							
Rechannel watercourse	1	1							
Totals	45	40	3	0	0	0	1	0	1
Percent	100	88.9	6.7	0	0	0	2.2	0	2.2

"I/E" = Implemented and Effective/No Problem Observed
"I/P" = Implemented and Problem or Potential Problem Exists
"I/UE" = Implemented and Unknown Effectiveness
"UI/E" = Unknown Implementation and Effective/No Problem Observed
"UI/P" = Unknown Implementation and Problem or Potential Problem Exists
"NI/E" = Not Implemented and Effective/No Problem Observed
"NI/P" = Not Implemented and Problem or Potential Problem Exists
"NI/U" = Not Implemented and Unknown Effectiveness

Table 42. Summary of recorded non-standard practices and additional mitigation measures for watercourse crossings.

Non-Standard Practice	Count	I/E	I/P	I/UE	UI/E	UI/P	NI/E	NI/P	NI/U
Rock road at crossing	4	2		1					1
Install 3/4 inch rock	1		1						
Rock Class III watercourse crossing	1	1							
Rock armor inlet of crossing	2	2							
Seed and mulch fill slopes at watercourse crossing	1		1						
Seed and mulch banks of removed crossing	1						1		
Straw mulch removed watercourse crossing	1	1							
Mulch 20 feet on either side of the crossing	1	1							
Seed and mulch road surface approaches to crossing	1	1							
Straw mulch new or reconstructed crossing	1			1					
Hydromulch fill slopes	2			2					
Use of existing watercourse crossing	2	2							
Install trash rack	1						1		
Install standpipe	2	2							
Remove 36 inch pipe, rock armor for slope stabilization	1	1							
Use of gravel ford crossing	1			1					
Install concrete sacks to stabilize downstream fill slope	1	1							
Install brow logs, berm logs	1						1		
Rechannel Class III watercourse along road	1	1							
Block road	1		1						
Totals	27	15	3	5	0	0	3	0	1
Percent	100	55.6	11.1	18.5	0	0	11.1	0	3.7

"I/E" = Implemented and Effective/No Problem Observed
"I/P" = Implemented and Problem or Potential Problem Exists
"I/UE" = Implemented and Unknown Effectiveness
"UI/E" = Unknown Implementation and Effective/No Problem Observed
"UI/P" = Unknown Implementation and Problem or Potential Problem Exists
"NI/E" = Not Implemented and Effective/No Problem Observed
"NI/P" = Not Implemented and Problem or Potential Problem Exists
"NI/U" = Not Implemented and Unknown Effectiveness

Table 43. Summary of recorded non-standard practices and additional mitigation measures for watercourse protection zones (WLPZs, ELZs, and EEZs). [see the previous tables for the definitions of the abbreviations used below]

Non-Standard Practice	Count	I/E	I/P	I/UE	UI/E	UI/P	NI/E	NI/P	NI/U
Use of existing WLPZ road for hauling	19	18		1					
Use of existing road and landing in WLPZ	1			1					
Reconstruction of road in WLPZ	1	1							
Use of existing WLPZ road for skidding logs	1	1							
Use of existing WLPZ skid trail	2	2							
Extreme EHR waterbreak spacing	1	1							
Seed and mulch existing WLPZ road	2	1							1
Slash pack skid trails	1	1							
Seed and mulch removed skid trail crossing	1	1							
Rocked road in WLPZ	3	3							
Rocked cross drains on WLPZ road	1	1							
No sidecast in WLPZ from existing road	1	1							
No harvesting in WLPZ	5	3		1					1
No harvesting in WLPZ except at cable corridors	1			1					
Equipment exclusion zone (EEZ) established	1	1							
EEZ 10 feet for Class III watercourse	1	1							
No equipment in WLPZ between road and stream	1	1							
No harvesting in WLPZ between road and stream	1	1							
Reduction in WLPZ width from 150 ft to 115 ft	1	1							
WLPZ width increased to 200 ft	2	2							
WLPZ width increased to 150 ft	1			1					
WLPZ width increased to 100 ft	1	1							
WLPZ width 150 ft; no variable zone based on slope	1							1	
Class II WLPZ 75 ft regardless of slope	1	1							
WLPZ width wider than standard Rule requirement	3	2		1					
WLPZ width--maximum distance possible in Rules	1	1							
75% retention of overstory vegetation	1	1							
70% overstory and 50% understory retention	1			1					
70% overstory retention	4		3	1					
70% total canopy retention	3	1	2						
50% canopy retention in ELZ for Class III watercourse	2			2					
Retain 5 largest trees in WLPZ	1	1							
Retain 5 trees/acre >32 inches DBH	1	1							
Very limited harvesting in WLPZ	2	2							
Removal of debris jams in channel	2	2							
Remove slash from WLPZ	1								1
Allow tree falling to occur across watercourse	2	1		1					
Exception to Rule requiring 2 conifers >16 in w/in 50 ft	1	1							
Totals	76	56	5	11	0	0	0	1	3
Percent	100	73.7	6.6	14.5	0	0	0	1.3	3.9

Discussion and Conclusions

Project Limitations

The Hillslope Monitoring Program has primarily reviewed Timber Harvesting Plans, with a very limited evaluation of Nonindustrial Timber Management Plans. Exemptions, Emergency Notices, and Conversions have not been monitored. The THP "Review Process" and the degree to which this process contributes to water quality problems has not been considered (Lee 1997). Also, since winter documentation of fine sediment delivery to streams was not possible with this program, the percentages of sediment delivery to watercourse channels from erosion features found on roads, landings, and skid trails are likely to underestimate total sediment delivery. Analysis completed on the data set to date has primarily been composed of frequency counts and has been limited by time and access to database analysts. Additional data analysis will be conducted in the future.

Key points regarding what has been learned are summarized and discussed below.

<u>Implementation rates of the Forest Practice Rules related to water quality are high, and individual practices required by the Forest Practice Rules are effective in preventing hillslope erosion features when properly implemented</u>.

Table 44 shows that overall ratings of the FPRs for each monitoring subject area are high—over 90% for all but watercourse crossings. This result is similar to what has been reported for other western states. For example average implementation rates for BMPs have been reported as 96 percent, 94 percent, and 92 percent in Oregon, Montana, and Idaho, respectively (Ice et al. 2002). In California, implementation of applicable Rules at problem points was nearly always (98% overall) found to be less than that required by the FPRs (Table 45). Therefore, problem points were almost always caused by non-compliance with the FPRs. These results are consistent with findings reported in earlier studies conducted in California (Dodge et al. 1976, CSWRCB 1987). The above conclusion refers to "individual practices," since the THP Review and inspection process was not evaluated as part of the Hillslope Monitoring Program.

Table 44. Summary of acceptable (i.e., meets or exceeds requirements) Forest Practice Rule implementation ratings for transects (roads, skid trails, watercourse protection zones) and features (landings and watercourse crossings) as a whole.

Hillslope Monitoring Program Sample Area	% Acceptable Implementation
Road Transects	**93.2**
Skid Trail Transects	**95.1**
Landings	**93.5**
Watercourse Crossings	**86.3**
Watercourse Protection Zones (WLPZ, ELZ, EEZ)	**98.4**
Total	**94.5**

Table 45. Summary of Forest Practice Rule implementation ratings at problem points for individual Hillslope Monitoring Program evaluation areas.

Hillslope Monitoring Program Sample Area	Percent Acceptable Implementation	Percent Major or Minor Departure from Requirements
Road Transects	**2**	**98**
Skid Trail Transects	**0**	**100**
Landings	**0**	**100**
Watercourse Crossings	**0**	**100**
Watercourse Protection Zones	**7**	**93**
Total	**2**	**98**

Watercourse crossing problems remain frequent, with nearly half the crossings evaluated having at least one problem point.

Large numbers of problem points were found at crossings. Reasons for this include:

- crossings are sometimes built incorrectly,
- many types of crossings have a relatively short expected life,
- culverts are sized with planned failure if a discharge event exceeds a selected recurrence interval (often 50 or 100 years),
- culverted crossings are often not built to properly accommodate large wood and sediment,
- maintenance of crossings—particularly culverts—is often difficult due to remote locations, lack of staff, and road passage problems in winter months,
- abandonment principles are subjective, difficult to apply in the field, and require considerable experience for proper implementation,
- upgrading old crossings can be very expensive, and
- shared use agreements on roads with crossings can complicate the responsibility and timing of improvement work.

The most frequent types of crossing problems encountered during the hillslope monitoring work were culvert plugging, diversion potential, fill slope gullies, scour at the outlet of the culvert, ineffective road surface cutoff waterbreaks, and fill slope mass failures. These problems are primarily related to the design, construction, and maintenance of crossings. Replacing and upgrading numerous crossings along a road segment can be a large, difficult, and expensive task for a landowner. Inventorying for the worst crossings with the most potential for adverse impacts to water quality and developing a plan to complete the work may be a realistic solution (see Flanagan et al. 1998). Gucinski et al. (2001) list several techniques for decreasing the negative hydrologic effects of roads, several of which relate to crossings.

Proper crossing abandonment requires considerable expertise and experience. Guidelines for accomplishing this work are provided in Weaver and Hagans (1994). Long-term sediment savings can be provided by removing crossings that will eventually fail (Madej 2001), but a small short-term flush of sediment is likely to occur during the first winter following heavy equipment work. Weaver (2001) estimated that this will often be on the order of 5 to 10 cubic yards per crossing.[28] Monitoring of crossing removal work in the Caspar Creek watershed found that an average of approximately 10 cubic yards was eroded from abandoned crossings during the first winter (excluding the one crossing in the South Fork that was retaining old splash dam deposits—see the Summary of Related Studies section earlier in this report for additional details).

Roads with drainage structure problems are the main cause of sediment delivery to stream channels.

About half the road transects evaluated by the Hillslope Monitoring Program field crews had one or more rills, approximately 25 percent had at least one gully, and four percent had a mass failure associated with the current plan. Forest Practice Rules related to these features were nearly always found to be out of compliance, usually due to drainage feature problems. Specifically, these problems were most often related to having: 1) inadequate size, number, and location of drainage structures to carry runoff water and minimize erosion, and 2) inadequate waterbreak spacing and waterbreak discharge into cover. About six percent of all evaluated drainage structures had problem points assigned to them. Gullies delivered sediment to channels about 24.5 percent of the time and rills about 12.6 percent of the time.

The monitoring results reported here are consistent with those described by MacDonald and Coe (2001—see the Related Studies section of this report). For their sites in the Central Sierra Nevada Mountains, they found that 16 percent of the segments and 20 percent of the road length had gullies or sediment plumes that were within 10 meters (32.8 feet) of a stream channel. In this study, contributing surface area multiplied by slope (A*S) was the best predictor of road surface erosion, and decreasing A*S by improving and maintaining road drainage was recommended to reduce erosion on native surfaced roads. In other words, proper spacing of rolling dips, waterbreaks, and where necessary, culvert cross drains, is a key component to reducing road surface erosion. Numerous publications have described techniques to reduce road surface erosion (see for example Burroughs and King 1989).

Hillslope monitoring results in Oregon are also consistent with data collected in California. Robben and Dent (2002) report that non-compliance with road related BMPs, especially drainage and maintenance requirements, was the largest source of sediment delivery to stream channels in their BMP compliance monitoring project. They also state that because the surveys were performed in the dry season, they likely underestimated the number of sediment delivery sources and total eroded volume. Skaugset and Allen (1998) stated that relief of road drainage at stream crossings was the most common source of sediment delivery in western Oregon. This study found that 25 percent of the surveyed road length delivered sediment directly to a stream channel. Additionally, Luce and Black (1999) found that sediment production was related to road surfaces, unvegetated ditches, and cutslope lengths draining to stream channels.

[28] This estimate was made based on field work conducted in Humboldt County.

Watercourse protection zones provide for adequate retention of post-harvest canopy and surface cover, and for prevention of harvesting related erosion.

Class I watercourses made up approximately 17 percent of the evaluated watercourses, 56 percent were Class IIs, and 27 percent were Class IIIs. Statewide, mean post-harvest total canopy cover exceeded 70 percent, regardless of instrument used for measurement. Mean total canopy exceeded Forest Practice Rule requirements in all three Forest Practice Districts, and was approximately 80 percent in the Coast Forest Practice District for both Class I and II watercourses. Surface cover exceeded 75 percent for all watercourse types in all three Forest Practice Districts. Required WLPZ widths generally met Rule requirements, with major departures from Rule requirements recorded only about one percent of the time. Additionally, the frequency of erosion events related to current timber operations in watercourse protection zones was very low for Class I, II, and III watercourses.

These results are consistent with the Modified Completion Report Monitoring program data collected by CDF Forest Practice Inspectors discussed earlier in the Related Studies section (Brandow 2002). Canopy measurements were remarkably similar for Class I and II watercourses in all three Forest Practice Districts. Similarly, erosion features related to the current operations in Class I and II WLPZs have been very rare.

With the federal listing of coho salmon as a threatened species in 1997 for the Southern Oregon/Northern California Coasts Coho ESU, it has been a common practice in the Coast Forest Practice District to either have 70 percent post-harvest canopy in Class I watercourses (CDF 1997) or prescribe no-harvest zones.[29] Greatly reduced harvesting within WLPZs has also been a common practice for interior area THPs in recent years. However, total canopy cover in the interior area is lower than on the Coast, which is probably due to past harvesting, slower conifer growth rates, and drier growing conditions for understory vegetation.

The monitoring work described in this report does not allow conclusions to be made regarding instream channel conditions for fish habitat (CSBOF 1999), and evaluating the biological significance of the Rules was not part of this program. For example, no relationship between post-harvest canopy levels and acceptable water temperatures for coldwater fish species can be determined from the data collected in this study. This type of monitoring has been and is currently being conducted in numerous locations throughout the state (see for example Lewis et al. 2000 and James 2001). Instream sediment production from timber operations conducted under the modern Forest Practice Rules, and impacts to macroinvertebrate communities and anadromous fish are available from the Caspar Creek watershed study (see Lewis et al. 2001, Rice et al. 2002, Bottorff and Knight 1996, Nakamoto 1998, and the summary provided in the

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[29] The July 2000 Threatened and Impaired Watersheds Rule Package approved by the BOF requires at least 85 percent overstory canopy post-harvest for the first 75 feet for planning watersheds with listed or candidate anadromous salmonid species, but THPs accepted by CDF after July 1, 2000 (when the Rule package went into effect) have not been included in the plans evaluated by the Hillslope Monitoring Program to date.

Related Studies section of this report). Additionally, research is underway by Drs. Mary Ann Madej (USGS) and Peggy Wilzbach (HSU) on the relative importance of size-specific, inorganic vs. organic components of the suspended load of streams and the influence of these components on stream health, as reflected in the efficiency of growth of juvenile salmonids and their invertebrate food base. This work is being conducted in the Caspar Creek and Redwood Creek watersheds of California. Data on large wood loading and recruitment in second-growth redwood/Douglas-fir watersheds found in the Coast Forest Practice District is available in Benda et al. (2002).

Landings and skid trails are not producing substantial impacts to water quality.

Erosion problems on landing surfaces, cut slopes, and fill slopes were relatively rare. Only about 11 percent of the landings evaluated were assigned problem points and the largest category of these occurrences was related to rills or gullies that formed from concentrated runoff below the outlet of a landing surface drainage structure. Dry season evidence of sediment delivery from landing surface drainage and fill slope erosion features to watercourse channels was recorded only seven and six times, respectively, from 569 landings.

Rill and gully erosion features on skid trails were found to deliver sediment to watercourse channels 3.8 percent and 13 percent of the time, respectively. Nearly all of these erosion problems were related to improper implementation of FPRs specifying installation of drainage structures. Low rates of sediment delivery from skid trails with properly installed and functioning drainage structures are not surprising, since earlier work in California has shown that skid trails used under the current Forest Practice Rules have not had a large impact on water quality. For example, Euphrat (1992) studied sediment transport related to timber harvesting in the Mokelumne River watershed in the central Sierra Nevada Mountains. The data he collected on numerous skid trails revealed that sediment was not transported to watercourses, and the data implied that relatively little material flowed off other well drained skid trail segments. Additionally, data collected by MacDonald and Coe (2001) in the central Sierra Nevada Mountains has shown that most harvest units (primarily tractor logged with skid trails) and landings produced relatively little sediment. Recently, Benda (2002) reported no erosion off well drained skid trails at the Southern Exposure research site in the Antelope Creek watershed in Tehama County.

The frequency of erosion events has decreased substantially in the last three years of the program.

The numbers of rills, gullies, mass failures and cutbank/sidecast sloughing features found on road, skid trail, and watercourse protection zone transects and the number of large erosion events decreased for the period from 1999 through 2001 when compared to 1996 through 1998. The primary reason for this decrease is probably reduced storm size, intensity, and frequency after the winter of 1997/1998. The January 1997 storm produced a 100-year discharge event in many Sierra Nevada Mountain watersheds, and was also a very significant event in the Coast Forest Practice District. For example, in southern Humboldt County in the Bull Creek basin, the January 1997 event is the flood of record, surpassing even the legendary December 1964 flood. The following winter of 1997/1998 (water year 1998) was a strong El Niño winter, with large, nearly continuous storm events. This hydrologic year produced the winter of record for total precipitation in the Caspar Creek watershed and produced numerous legacy road related landslide features in the South Fork basin (Cafferata and Spittler 1998). Maximum annual instantaneous peak discharge values for three free flowing stream systems located throughout Northern and Central California are displayed in Figure 23 and show much higher values in water years 1995, 1996, and 1997, when compared to those that occurred in 1998 through 2001. Therefore, it is possible to conclude that the Hillslope Monitoring Program study period has included large stressing storm events that have tested the Forest Practice Rules related to water quality—particularly in the first three years of the project.

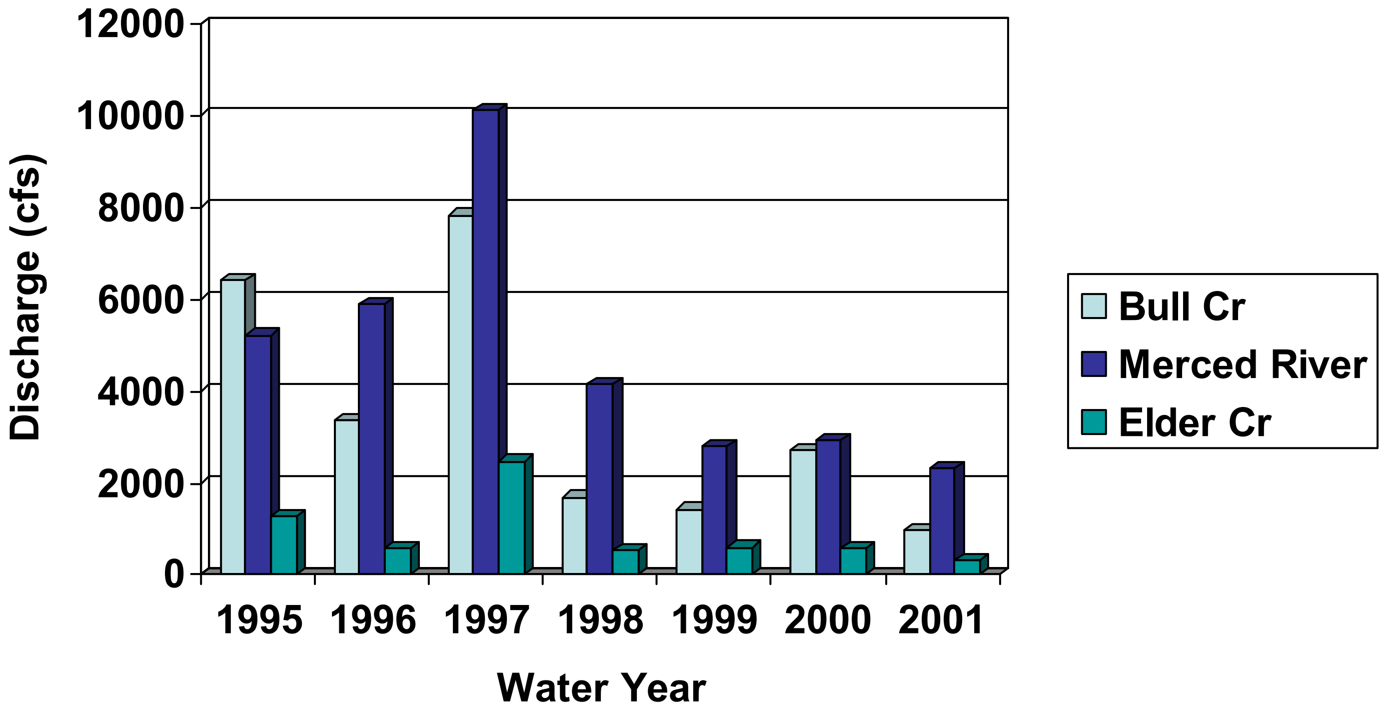

Figure 23. Stream gauging station maximum annual instantaneous peak discharge data for three free flowing river systems. The Merced River at Happy Isles is located in Yosemite National Park in the central Sierra Nevada Mountains, Bull Creek is located in southern Humboldt County, and Elder Creek is located in western Mendocino County.

The connection between storm size and intensity and the frequency of erosion features is supported by the results that Coe and MacDonald (2002), who noted large interannual variability in sediment production rates over three years of monitoring at their central Sierra Nevada sites, and attributed these differences to the magnitude and type of the precipitation. For example, sediment production for the 1999-2000 winter was 3 to 11 times higher than the sediment production rates for the 2000-2001 winter.

Additional reasons for reduced erosion feature frequency for the second three year period include increased familiarity with field methods and a change in the THP selection process. The lead contractor for the project, Mr. Roger Poff, has stated that rilling on road and skid trail transects may have been overestimated during the first two years (1996 and 1997) of the project, primarily because of the complexity of the data recording process and the learning curve required to successfully complete adequate data collection. Rills were not usually measured to determine if they met the stated criteria for this type of feature and were probably tallied too frequently (R.J. Poff, personal communication). Also, there were more small non-industrial landowner THPs and NTMP projects, with generally smaller plan size for the period from 2000 to 2001, which probably reduced the opportunity for finding the various types of erosion features.

The Hillslope Monitoring Program results to date are similar to data collected on CDF violations for THPs related to water quality.

Water quality violations of the Rules are identified and corrected, where possible, as part of the normal CDF Forest Practice Inspection process. Information from CDF's Forest Practice Program Database shows that 975 violations were issued on the 4,749 THPs open from 1998 through 2000.[30] These violations can be separated into three basic groups: harvesting practices and erosion control (347), watercourse and lake protection (308), and logging roads and landings (320). The FPRs with the highest number of violations generally involved waterbreak requirements, timber operations in the winter period, proper removal of temporary crossings, roads and landings located outside of WLPZs, removal of debris from very small watercourses, WLPZ trees felled away from the watercourse, removal of accidental depositions in watercourses, crossings open to unrestricted passage of water, size/number/location of drainage structures adequate to minimize erosion, and crossing removal adequate to prevent erosion. This type of information complements the data from the Hillslope Monitoring Program and CDF's Modified Completion Report monitoring work. Together, these three independent data sources allow cross-checking and corroboration of the results of each type of monitoring (Ice et al. 2002).

[30] This data analysis was completed by Mr. Clay Brandow, CDF, Sacramento.

Several reasons exist for why THPs with approved Work Completion Reports can have relatively high percentages of total departures from Forest Practice Rule requirements.

The deviations from the FPRs reported in the 1999 Interim Report (CSBOF 1999) for THPs with approved Work Completion Reports has prompted criticism of the adequacy of the CDF's inspection and enforcement program (see for example, Stillwater Sciences 2002). Reasons for these post-inspection Rule problems include:

- CDF Forest Practice Inspectors focus on the whole THP to identify threats to water quality and often will not find minor departures. Most of the Rule departures associated with problem points in the six years of hillslope monitoring have been minor departures with little or no direct impact to water quality. Of all the total number of departures for the problem point sites, 76.5 percent have been minor and 23.5 percent major departures. The category with the highest percentage of major departures is watercourse crossings, with approximately 49 percent major departures at identified problem points.

- CDF inspectors must balance the time necessary to enforce the repairing of a single or small problem against forgone inspections on other plans where there may be significant numbers of problems or a significant consequence from a problem.

- Some FPRs are qualitative in nature, and a minor deviation identified in the Hillslope Monitoring Program when an erosion feature is found would not necessarily trigger a rule violation by CDF during an inspection before the erosion occurred. A common example of this type of Rule is 14 CCR 923.2(h) [943.2(h), 963.2(h)], which requires drainage structures of sufficient size, number and location to minimize erosion.

- In the Hillslope Monitoring Program, major departures are assigned for sediment delivery with or without a significant departure from Rule requirements.

Several steps have been taken to improve implementation of the FPRs related to water quality since 1999. These include implementation of the Modified Completion Report monitoring process by CDF Forest Practice Inspectors in 2000 (see discussion on this program in the Related Studies section of this report), BOF passage of a rule requiring RPF supervision of active logging operations in 2000,[31] and information dissemination/ training related to monitoring results provided to CDF Foresters and RPFs in California.

[31] This Rule was passed by the BOF in 2000 and went into effect on January 1, 2001. See 14 CCR 1035.1, Registered Professional Forester Responsibility.

Preliminary results on the use of non-standard practices and additional mitigation measures indicate the need for more thorough inspection and a more focused study design to adequately examine the implementation and effectiveness of these practices.

The determination of whether proposed non-standard practices (i.e., alternatives, in-lieus, exceptions, etc., collectively referred to as non-standard practices) and additional mitigation measures are appropriate for a given site is a major component of the Timber Harvesting Plan Review Process, so there is clearly a need for monitoring the adequacy of these practices. However, the focus of the Hillslope Monitoring Program has been on evaluating the adequacy of standard Forest Practice Rules, so results from the limited data collected on non-standard practices should be considered as preliminary.

The data collected to date show that existing or potential problems were found on approximately 15 percent of road transects, 7 percent of landings, 11 percent of crossings, 9 percent of skid trail transects, and 8 percent of watercourse protection zone transects where non-standard practices and additional mitigation measures were prescribed. Improper implementation of these practices was 13 percent on roads, 25 percent on skid trails, 4 percent on landings, 15 percent at crossings, and 5 percent for watercourse protection zones. These results are consistent with the findings for the standard Forest Practice Rules for watercourse protection zone transects, with both standard and non-standard Rules having high overall implementation ratings and few problems. Additionally, these preliminary results suggest that better implementation of non-standard practices could be achieved with more thorough inspection by RPFs and CDF Forest Practice Inspectors.

The California Forest Practice Rule requirements with the lowest overall implementation related to water quality have been identified and education efforts related to these Rules are required.

To focus on areas where improvement in Rule design or implementation would provide the greatest benefits to water quality, Table 46 summarizes the 20 Forest Practice Rule requirements with four percent or more major departures (the table shows 24 Rule requirements, but one Rule was cited for both roads and landings[32], and three Rules were cited for both roads and crossings). The need for improved implementation of these Rule requirements, in particular, should be made known to RPFs, LTOs, and CDF Forest Practice Inspectors. Seven rule requirements relate to roads, one to skid trails, two to landings, 13 to watercourse crossings, and one to watercourse protection zones.

[32] Note that 14 CCR 923.1(a) is a THP mapping requirement and does not directly cause an adverse impact water quality.

Table 46. Forest Practice Rule requirements with at least four percent major departures based on at least 30 observations where implementation could be rated (note this table was developed from Tables 6, 14, 22, 25, and 29).

Location	Rule No.	Description of Rule	Major Departure %
Roads	914.6(f)	where waterbreaks do not work--other erosion controls installed	4.2
Roads	923.1(f)	adequate numbers of drainage structures to minimize erosion	4.8
Roads	923.2(h)	size, number, and location of structures sufficient to carry runoff water	5.3
Roads	923.1(a)	landing on road greater than ¼ acre or requiring substantial excavation--shown on THP map	11.5
Roads	923.2(h)	size, number, and location of structures sufficient to minimize erosion	4.1
Roads	923.2(d) Coast	fills constructed with insloping approaches, berms, rock armoring, etc., to minimize erosion	4.7
Roads	923.2(m)	sidecast extending greater than 20 feet with access to a watercourse protected by a WLPZ treated to reduce erosion	7.4
Skid Trails	914.6(c)	waterbreak spacing equals standards	5.6
Landings	923.1(a)	landings greater than ¼ acre or requiring substantial excavation--shown on THP map	10.9
Landings	923.5(f)(4)	sidecast or fill extending greater than 20 feet with access to watercourse—treated to reduce erosion	4.3
Crossings	923.2(o)	no discharge on fill unless suitable energy dissipators are used	12.6
Crossings	923.2(h)	size, number, and location of structures minimizes erosion	11.2
Crossings	923.2(d) Coast	fills across channels built with insloping approaches, berms, rock armoring, etc., to minimize erosion	9.8
Crossings	923.4(n)	crossing/approaches maintained to avoid diversion	4.0
Crossings	923.8	abandonment—minimize concentration of runoff	4.6
Crossings	923.3(e)	crossing/fills built to prevent diversion	5.5
Crossings	923.4(d)	crossing open to unrestricted passage of water	4.0
Crossings	923.8(d)	abandonment--pulling/shaping of fills	9.8
Crossings	923.8(c)	abandonment--grading of road for dispersal of water flow	4.8
Crossings	923.3(d)(2)	removed--cut bank sloped back to prevent slumping and to minimize soil erosion	6.3
Crossings	923.8(b)	abandonment--stabilization of exposed cuts/fills	4.8
Crossings	923.2(h)	size, number, location of structures sufficient to carry runoff	7.1
Crossings	923.8(e)	abandonment--fills excavated to reform channel	5.1
WLPZs	916.2(a)(4)	sensitive conditions--existing roads in WLPZ—appropriate mitigation measure(s) applied	4.5

Recommendations

Based on the results compiled from six years of Hillslope Monitoring Program data, we recommend the following items:

TRAINING

1. Develop robust training programs based on monitoring results for LTOs, RPFs, CDF Forest Practice Inspectors, and members of other reviewing agencies. Training program agendas will be tailored to the needs of the various targeted audiences.

2. Require more thorough and consistent inspection of watercourse crossings by CDF Forest Practice Inspectors and other reviewing agencies based on the above training programs.

3. Inform CDF Forest Practice Inspectors on monitoring results at the annual CDF Forest Practice enforcement training course in Fort Bragg. Note that while the course is offered annually, each Inspector attends the class every four years. Additionally, inform CDF Forest Practice Inspectors of monitoring results and needed improvements at annual forester meetings.

4. Develop a Licensed Timber Operator (LTO) implementation guidance document for installation of watercourse crossings and road drainage structures. This effort should be coordinated with the other reviewing agencies, particularly the California Department of Fish and Game. The goal is to produce a relatively simple document that quickly and simply illustrates the most important principles for successful crossing and drainage structure design and installation. For example, some of the concepts to include for crossings would be proper: gradient, alignment, diversion potential, pipe length, armoring, etc.

5. Raise awareness of key hillslope monitoring findings to forest landowners, the public, Licensed Timber Operators, RPFs, and other interested parties. This is to be accomplished through updates provided to the BOF's Licensing News, the CLFA Update, CDF Mass Mailings to RPFs, and other regularly produced newsletters.

6. Work with the California Licensed Foresters Association (CLFA), Associated California Loggers (ACL), Forest Landowners of California (FLOC), the California Forestry Association (CFA), and other forestry related trade associations to develop workshops that address key issues identified through hillslope monitoring. For example, a CLFA workshop on watercourse crossings is scheduled for March, 2003.

ROAD MANAGEMENT PLAN

7. Upgrade those watercourse crossings with problems, including old, existing structures, with a voluntary, cooperative Road Management Plan, including an agreed to schedule to complete upgrading work.

MODIFICATIONS FOR THE HILLSLOPE MONITORING PROGRAM

8. Revise the Hillslope Monitoring Program to adequately examine: 1) additional mitigation measures applied to THPs, and 2) non-standard practices applied to THPs (including in-lieu and alternative practices).

9. Revise the Hillslope Monitoring Program to: 1) address the changes in the Forest Practice Rules since the BOF passed the Threatened and Impaired Watersheds Rule Package in July 2000, and 2) reduce emphasis on semi-qualitative assessments by conducting more rigorous and scientifically defensible tests of individual practice effectiveness (e.g., pre and post-harvest, overstory/understory, conifer/hardwood canopy data; detailed information on watercourse crossings built as part of the current plan under the Threatened and Impaired Watersheds Rule Package, allowing for passage of wood and sediment as well as 100-year flood flows; and detailed information on newly constructed road drainage structures, including contributing surface area, slope, surfacing, grading, erosion problems, sediment delivery, etc.).

WORK NEEDED TO COMPLEMENT THE HILLSLOPE MONITORING PROGRAM

10. Continue to support the implementation and funding of instream monitoring projects that have a peer-reviewed study design, including pre-project data collection, to answer questions about Forest Practice Rule effectiveness and compliance with Regional Water Quality Control Board Basin Plan standards.

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Glossary

Abandonment – Leaving a logging road reasonably impassable to standard production four wheel-drive highway vehicles, and leaving a logging road and landings, in a condition which provides for long-term functioning of erosion controls with little or no continuing maintenance (14 CCR 895.1).

Alternative practice – Prescriptions for the protection of watercourses and lakes that may be developed by the RPF or proposed by the Director of CDF on a site-specific basis provided that several conditions are complied with and the alternative prescriptions will achieve compliance with the standards set forth in 14 CCR 916.3 (936.3, 956.3) and 916.4(b) [(936.4(b), 956.4(b)]. 14 CCR 916.6 (936.6, 956.6). More general alternative practices are permitted under 14 CCR 897(e).

Beneficial uses of water – As described in the Porter-Cologne Water Quality Control Act, beneficial uses of water include, but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish and wildlife, and other aquatic resources or preserves. In Water Quality Control Plans, the beneficial uses designated for a given body of water typically include: domestic, municipal, agricultural, and industrial supply; industrial process; water contact recreation and non-water contact recreation; hydropower generation; navigation; groundwater recharge; fish spawning, rearing, and migration; aquatic habitat for warm-water species; aquatic habitat for coldwater species; and aquatic habitat for rare, threatened, and/or endangered species (Lee 1997).

Best management practice (BMP) - A practice or set of practices that is the most effective means of preventing or reducing the generation of nonpoint source pollution from a particular type of land use (e.g., silviculture) that is feasible, given environmental, economic, institutional, and technical constraints. Application of BMPs is intended to achieve compliance with applicable water quality requirements (Lee 1997).

Canopy - the foliage, branches, and trunks of vegetation that blocks a view of the sky along a vertical projection. In the Hillslope Monitoring Program, this was estimated from 1996 through1998 with a spherical densiometer and from 1999 through 2001 with a sighting tube. The Forest Practice Rules define canopy as “the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody species” (14 CCR 895.1).

Cutbank/sidecast sloughing – Shallow, surficial sliding associated with either the cutbank or fill material along a forest road or skid trail, with smaller dimensions than would be associated with mass failures.

Feature - Any constructed component of a landing, road, skid trail, or watercourse crossing (e.g., cut bank, fill slope, inside ditch, cross drain, water break).

Exception – A non-standard practice for limitations on tractor operations (14 CCR 914.2(f)(3), 934.2(f)(3), 954.2(f)(3)).

Gully - Erosion channels deeper than 6 inches (no limitation on length or width). Gully dimensions were estimated.

In-lieu practice – These practices apply to Rule sections for watercourse protection where provision is made for site specific practices to be proposed by the RPF, approved by the Director and included in the THP in lieu of a stated Rule. The RPF must reference the standard Rule, explain and describe each proposed practice, how it differs from the standard practice, indicate the specific locations where it will be applied, and explain and justify how the protection provided by the proposed practice is at least equal to the protection provided by the standard Rule (14 CCR 916.1, 936.1, 956.1).

Large erosion event - These events were defined for the Hillslope Monitoring Program as 100 cubic yards for a mass failure void left on a hillslope, or at least 10 cubic yards for catastrophic crossing failures.

Mass failure – Downslope movement of soil and subsurface material that occurs when its internal strength is exceeded by the combination of gravitational and other forces. Mass erosion processes include slow moving, deep-seated earthflows and rotational failures, as well as rapid, shallow movements on hillslopes (debris slides) and in downstream channels (debris torrents).

Minor/major departure – Major departures were assigned to problem points when sediment was delivered to watercourses, or when there was a substantial departure from Rule requirements (e.g., no or few waterbreaks installed for an entire transect). Minor departures were assigned for slight Rule departures where there was no evidence that sediment was delivered to watercourses (e.g., WLPZ width slightly less than that specified by the Rule).

Non-standard practice - A practice other than a standard practice, but allowable by the Rules as an alternative practice, in-lieu practice, waiver, exclusion, or exemption (Lee 1997).

Parameter - The variable being studied by sampling, observation, or measurement (Lee 1997).

Permanent road – A road which is planed and constructed to be part of a permanent all-season transportation facility. These roads have a surface which is suitable for the hauling of forest products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flow. Normally they are maintained during the winter period (14 CCR 895.1). After July 1, 2000, watercourse crossings associated with permanent roads have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Problem point - In the Hillslope Monitoring Program the occurrence of: 1) erosion features (rills, gullies, mass failures, or cutbank/sidecast sloughing) found at sample sites or along transects, 2) canopy reduction, streambank erosion, or ground cover reduction in a watercourse protection zone, or 3) Forest Practice Rule violations (e.g., waterbreak improperly constructed) (Lee 1997).

Process - The procedures through which the Rules/BMPs are administered and implemented, including: (a) THP preparation, information content, review and approval by RPFs, Review Team agencies, and CDF decision-makers, and (b) the timber operations completion, oversight, and inspection by LTOs, RPFs, and CDF inspectors (Lee 1997).

Quality assurance - The steps taken to ensure that a product (i.e., monitoring data) meets specified objectives or standards. This can include: specification of the objectives for the program and for data (i.e., precision, accuracy, completeness, representativeness, comparability, and repeatability), minimum personnel qualifications (i.e., education, training, experience), training programs, reference materials (i.e., protocols, instructions, guidelines, forms) for use in the field, laboratory, office, and data management system (Lee 1997).

Quality control - The steps taken to ensure that products which do not meet specified objectives or standards (i.e., data errors and omissions, analytical errors) are detected and either eliminated or corrected (Lee 1997).

Repeatability - The degree of agreement between measurements or values of a monitoring parameter made under the same conditions by different observers (Lee 1997).

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997). Forest Practice Rules are included in Title 14 of the California Code of Regulations (14 CCR).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (14 CCR 895.1). After July 1, 2000, all permanent watercourse crossings have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Standard practice - A practice prescribed or proscribed by the Rules (Lee 1997).

Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (14 CCR 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (14 CCR 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted. Waterbreaks are synonymous with waterbars (14 CCR 895.1).

Appendix

Table A-1. Landings--effectiveness ratings.

Evaluation Category	Number of Observations	Description
Surface Rilling and Gullying		
a. Rilling on Landing Surface	430	None
	79	Less than 1 rill/100 ft (0-20%)
	16	Some rilling (less than 1 rill/20 ft of transect)
	0	Greater than 1 rill/20 ft (greater than 20%)
	2	Greater than 20% of landing drained by rills
	41	0-20% of landing drained by rills
b. Gullies on Landing Surface	461	None
	90	Less than 1 gully per 100 ft transect
	3	Some gullying (less than 1 gully per 20 ft of transect)
	0	Gullying that exceeds 1 gully per 20 ft of transect
	11	Gullying present with recorded dimensions
Surface Drainage		
a. Drainage Runoff Structure	270	No evidence of erosion from concentrated flow where drainage leaves landing surface or drainage outlet
	54	Rills or gullies present but do not extend greater than 20 ft below edge of landing or drainage outlet
	24	Presence of rills or gullies which extend greater than 20 ft below edge of landing or drainage outlet
b. Sediment Movement	325	No evidence of transport to WLPZ
	14	Sediment deposition in WLPZ but not to channel
	7	Evidence of sediment transport to, or deposition in channel
Landing Cut Slopes		
a. Rilling	274	No evidence of rills
	15	Rills present but do not extend to drainage structure or ditch
	5	Rills present and extend to drainage structure or ditch
b. Gullies	289	No evidence of gullies
	1	Gullies present but do not extend to drainage structure or ditch
	4	Gullies present and extend to drainage structure or ditch

Evaluation Category	Number of Observations	Description
Landing Cut Slopes		
c. Slope Failures	272	Less than 1 cubic yard of material moved
	18	More than 1 cubic yard moved but it is not transported to drainage structure or ditch
	3	More than 1 cubic yard moved, some material transported to drainage structure or ditch
Landing Fill Slopes		
a. Rilling	332	No evidence of rills
	42	Rills present but do not extend to drainage channels below toe of fill
	2	Rills present and extend to drainage channels below toe of fill
b. Gullies	345	No evidence of gullies
	26	Gullies present, but do not extend to drainage channels below toe of fill
	5	Gullies present and extend greater than a slope length below toe of fill
c. Slope Failures	355	No material moved
	12	Less than 1 cubic yard moved
	8	More than 1 cubic yard moved but does not enter channel
	2	More than 1 cubic yard moved, some material enters channel
d. Sediment Movement	363	No evidence of transport to WLPZ
	8	Sediment deposition in WLPZ but not carried to channel
	6	Evidence of sediment transport to, or deposition in channel

Table A-2. Crossings--effectiveness ratings.

Evaluation Category	Number of Observations	Description
Fill Slopes at Crossings		
a. Vegetative Cover	285	Vigorous dense cover or fillslope of stable material
	101	Less than full cover, but greater than 50% if fillslope has effective cover or is of stable material
	24	Less than 50% of fillslope has effective cover or is of stable material
b. Rilling	332	Rills may be evident, but are infrequent, stable and no evidence of sediment delivery to channel
	46	Few rills present (less than 1 rill per lineal 5 ft) and not enlarging, with little apparent deposition in channel
	32	Numerous rills present (greater than 1 rill per lineal 5 ft), apparently enlarging or with substantial evidence of delivery to channel
c. Gullies	344	None
	14	Gullies present, not enlarging, little apparent deposition in channel
	12	Gullies present and enlarging or threatening integrity of fill
	40	Gully with dimensions provided
d. Cracks	378	None evident
	22	Cracks present, but appear to be stabilized
	7	Cracks present and widening, threatening integrity of fill
e. Slope Failure	302	None
	64	Less than 1 cubic yard (lowest category available in 1996, “none” was not available)
	18	0 to 1 cubic yard of material
	27	Greater than 1 cubic yard of material
Road Surface Draining to Crossings		
a. Rutting	403	No ruts present
	61	Some ruts present, but design drainage not impaired
	13	Rutting impairs road drainage
b. Rilling	433	Little or no evidence of rills
	32	Rills occupy less than 10% of road surface area, or do not leave road surface
	11	Rills occupy greater than 10% of surface and continue off road surface onto crossing or fill
c. Gullies (>6 in deep)	383	None
	8	Gully with dimensions provided

Evaluation Category	Number of Observations	Description
d. Surfacing of Crossing Approach	359	No loss of road surface
	31	Less than 30% of road surface area degraded by surface erosion
	5	Greater than 30% of road surface area degraded by surface erosion
e) Cut-off Waterbar Condition	248	Functional
	49	Allows some water to reach crossing location
	25	Allows all water running down the road to reach crossing location
f) Inside Ditch Condition	107	Open
	19	Some sediment/debris accumulation
	6	Blocked with sediment/debris
g. Ponding	400	No evidence of ponded water
	61	Ponding present, but does not appear to threaten integrity of fill
	12	Ponding present and is causing fill subsidence or otherwise threatening integrity of fill
h. Road Surface Drainage	53	Stable drainage with little or no sediment delivery to stream
(only used in 1996)	22	Slight sediment delivery but configuration is stable or stabilizing
	8	Continuing sediment delivery to stream and configuration is unstable/degrading
Culverts		
a. Scour at Inlet	316	No evidence of scour
	15	Scour evident but extends less than 2 channel widths above inlet and no undercutting of crossing fill
	5	Scour evident that extends more than 2 channel widths above inlet or scour is undercutting crossing fill
b. Scour at Outlet	226	No evidence of scour
	74	Scour evident, but extends less than 2 channel widths below outlet, and no undercutting of crossing fill
	36	Scour evident that extends more than 2 channel widths below outlet, or scour undercuts crossing fill
c. Diversion Potential	243	Crossing configured to minimize fill loss (road doesn't slope downward from crossing in at least one direction)
	62	Crossing has road that slopes downward in at least one direction with drainage structure
	30	If culvert fails, flow will be diverted out of channel and down roadway
d. Plugging	257	No evidence of sediment or debris
	50	Sediment and/or debris is accumulating, less than 30% of inlet or outlet is blocked
	29	Sediment and/or debris is blocking greater than 30% of inlet or outlet

Evaluation Category	Number of Observations	Description
e. Alignment	270	Appropriate
	2	Low angle channel approach
	3	High angle channel approach or discharge is not in channel
f. Degree of Corrosion	222	None to slight (metal discolored but not missing)
	18	Moderate--some corroded metal missing but pipe still competent
	2	Severe--pipe can be punctured with screwdriver or similar tool
g. Crushed Inlet/Outlet	251	None
	23	Pipe deformed but less than 30% of inlet/outlet blocked
	1	Pipe deformed and greater than 30% of inlet/outlet blocked
h. Pipe Length	323	Appropriate
	10	Length causing only minor amount of gullying or fill slope erosion
	2	Length directly related to large gullies or fillslope erosion around pipe
i. Gradient	230	Appropriate--at base of fill and at grade of original streambed
	26	Pipe inlet set slightly too low or slightly too high in fill
	21	Pipe inlet set too high or too low, causing debris accumulation, or water to under cut the culvert
j. Piping	263	No evidence of flow beneath or around culvert
	14	Flow passes beneath or around culvert, or piping erosion evident
Non-Culvert Crossing		
a. Armoring	60	Appropriate
	12	Minor downcutting evident at crossing due to inadequate armoring
	8	Major downcutting evident at crossing due to inadequate armoring
b. Scour at Outlet	59	No evidence of scour
	19	Scour evident, but extends less than 2 channel widths below outlet, and no undercutting of crossing fill
	6	Scour evident that extends more than 2 channel widths below outlet, or scours undercuts crossing fill
c. Diversion	77	Crossing configured to minimize fill loss (road does not slope downward from crossing in at least one direction)
	3	Crossing has road that slopes downward in at least one direction but is unlikely to divert flow down road
	3	Overflow will be diverted down road

Evaluation Category	Number of Observations	Description
Removed or Abandoned		
a. Bank Stabilization	60	Vigorous dense vegetation cover or other stabilization material
	21	Less than full cover, but greater than 50% of channel bank has effective cover or has stable material
	4	Less than 50% of channel bank has effective cover or is composed of stable material
b. Rilling of Banks	79	Rills may be evident but infrequent, stable, with no sediment delivery to channel
	5	Few rills present (less than 1 per lineal 5 ft) and rills not enlarging
	1	Numerous rills present (greater than 1 rill per lineal 5 ft) or apparently enlarging
c. Gullies	80	None evident
	5	Gully with dimensions provided
d. Slope Failures	82	Less than 1 cubic yard of material
	2	Greater than 1 cubic yard of material moved but does not enter stream
	1	Greater than 1 cubic yard of material moved, material enters stream
e. Channel Configuration	69	Wider than natural channel and close to natural watercourse grade and orientation
	12	Minor differences from natural channel in width, grade, or orientation
	3	Narrower than natural channel width, or significant differences from natural channel grade or orientation
f. Excavated Material	77	Sloped to prevent slumping and minimize erosion
	4	Slumps or surface erosion present, but less than 1 cubic yard of material enters channel
	1	Slumps or surface erosion present, greater than 1 cubic yard of material enters channel
g. Grading and Shaping	72	No evidence of erosion or sediment discharge to channel due to failures of cuts, fills or sidecast
	10	Less than 1 cubic yard of material transported to channel due to failures of fills or sidecast
	2	Greater than 1 cubic yard material transported to channel due to failures of fills or sidecast
Road Approaches at Abandoned Crossings		
a. Grading and Shaping	60	No evidence of concentrated water flow to channel from road surface (in excess of designed drainage or erosion of drainage facility)
	9	Less than 1 cubic yard of material transported to channel from eroded surface soil on road approaches
	2	Greater than 1 cubic yard of material transported to channel from eroded surface soil on road approaches

INTERIM REPORT TO THE CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

HILLSLOPE MONITORING PROGRAM:

MONITORING RESULTS FROM 1996 THROUGH 1998

PREPARED BY THE MONITORING STUDY GROUP OF THE CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

JUNE 1999
SACRAMENTO, CALIFORNIA

EXECUTIVE SUMMARY

The Monitoring Study Group was created by the California State Board of Forestry and Fire Protection to determine how effective the Forest Practice Rules are in protecting water quality. The California Department of Forestry and Fire Protection (CDF) implemented hillslope monitoring in 1996 on 50 randomly selected Timber Harvesting Plans (THPs) in Humboldt and Mendocino Counties to provide information on forest practices within the range of coho salmon. The program expanded in 1997 and 1998, with 50 randomly selected THPs evaluated each year throughout the state. Field work on all 150 THPs was conducted by private contractors who were Registered Professional Foresters with significant amounts of experience developing THPs and using the Forest Practice Rules. An earth scientist was required to be part of the contractor's field team for the state-wide work.

THPs selected for hillslope monitoring had to: 1) have been accepted for filing under the revised Forest Practice Rules after October 1991, 2) have been through at least one but not more than four winters since logging was completed, 3) have been logged with crawler tractors and/or cable yarding systems, and 4) contain at least 500 continuous feet of a Class I or II watercourse. A randomly selected pool of THPs was generated and permission for access was requested. Access was granted by large industrial landowners for all but one THP, but roughly one-third of the small-nonindustrial landowners failed to grant access. About 65% of the sampled THPs were on large industrial timberlands, and 35% had non-industrial timberland owners or other types of ownership (state, small companies, etc.). The Coast Forest Practice District contained 66% of the THPs, while the Northern and Southern Districts had 22 and 12%, respectively. Only THPs were evaluated (no Emergencies, Exemptions, or Non-industrial Timber Management Plans were included).

Evaluation of individual THPs occurred at five sample areas that past studies indicated were the greatest risk to water quality—roads, skid trails, landings, watercourse crossings, and watercourse and lake protection zones (WLPZs). Comprehensive forms were developed for recording site information, implementation data, and effectiveness data for each of these five sample areas. In total, 190 Forest Practice Rule requirements that could be determined by field review were evaluated. The data in this report are only for the standard Rules (not alternatives or in-lieu practices). Class III protection, impacts from winter operations, and restorable uses of water (three areas referred to in CDF's 1995 survey report on watercourse protection as having concern for proper implementation and effectiveness) have not been addressed by this project except where intersected by erosion features that also involve one of the previously described sample areas.

All five sample areas were evaluated twice within each THP if possible. Roads, skid trails and WLPZs were sampled using transects that were 1000 feet in length when available (in all cases they were at least 500 feet long). Landings and watercourse crossings were evaluated as individual features without transects. All sample areas were randomly located within the THP. Large erosion events were inventoried when they were encountered on a THP. Implementation of the Forest Practice Rules applicable to a given sample site was rated as either exceeding the Rule requirements, meeting the requirements, minor departure from requirements, or major departure from requirements (with other categories for not applicable, etc.). Major departures were assigned when sediment was delivered to watercourses, or when there was a substantial departure from Rule requirements. In contrast, minor departures were assigned for slight Rule departures when there was no evidence that sediment was delivered to watercourses.

Results to date have been developed from frequency counts. As this program continues, additional analyses may be performed to determine if there are significant differences between Rule applications and site or operator factors. It is also important to note that the results apply only to implementation and effectiveness on hillslope locations—and are not directly linked to current instream conditions.

Roads and their associated crossings were found to have the greatest potential for sediment delivery to watercourses. Twenty-two road Rule requirements had either minor or major departures for implementation more often than 5% of the time (based on a sample of at least 30 observations where implementation could be rated). Similarly, 14 Rule requirements for crossings had minor or major departures that exceeded the 5% level. Most of the road Rule implementation departures fell within the minor departure category, while a larger proportion of the crossing Rule implementation ratings were for major departures. Results to date indicate that greater attention should be focused on improvement of crossing design, construction, and maintenance due to the high levels of departures from Rule requirements and the close proximity of crossings to channels. For roads, better implementation of Rules related to drainage structure design, construction, and maintenance is needed. Mass failures associated with current timber operations were mostly related to roads and produced the highest sediment delivery to watercourse channels when compared to other erosion processes. The majority of the road related mass failures were associated with fill slope problems—indicating that proper road construction techniques are critical for protecting water quality.

Watercourse and lake protection zones generally met Forest Practice Rule requirements for width, canopy, and ground cover. Very few erosion features associated with current THPs were recorded within WLPZs. Six rule requirements for WLPZs had either minor or major departures for implementation more often than 5% of the time, but the vast majority of the departures were in the minor category.

Landings had few erosion features associated with current operations and generally did not deliver significant amounts of sediment to watercourses. Four landing Rule requirements had either minor or major departures for implementation more often than 5% of the time, and most ratings were within the minor category. Impacts from skid trails were also relatively minor compared to those produced by roads and crossings. Frequency of erosion problem points on skid trails was much lower than that documented on road transects. Only three skid trail Rule requirements had either minor or major departures for implementation that exceeded 5% of the observations. The majority of the departures fell within the minor category.

Several general observations regarding the Hillslope Monitoring Program and the preliminary results that have been produced were made by the Monitoring Study Group. These observations include the need to: (1) develop training programs for Registered Professional Foresters, Licensed Timber Operators, and equipment operators about the Forest Practice Rules that were found to have the poorest implementation, (2) continue monitoring in order to test infrequently encountered Forest Practice Rules and infrequent natural events, (3) continue monitoring to provide a sufficient sample size to evaluate non-standard (i.e., in-lieu and alternative) practices, (4) evaluate current quality assurance/quality control (QA/QC) information and determine what additional work needs to be completed, and (5) complete a more in-depth analysis of the existing hillslope monitoring data set.

In summary, the Forest Practice Rules and individual THP requirements (i.e., site-specific mitigation measures developed through recommendations of interagency Review Teams) were generally found to be sufficient to prevent hillslope erosion features. The Hillslope Monitoring Program results, however, do not allow us to draw conclusions about whether the existing Rules are providing properly functioning habitat for aquatic species because evaluating the biological significance of the current Rules was not part of this project. For all five sample areas, erosion problem points were almost always associated with improperly implemented Forest Practice Rules. In other words, nearly all of the erosion problems resulted from non-compliance. These conclusions are similar to those reached in the “208 Team” report (SWRCB 1987), where it was reported that the standard practices in the Rules generally appeared to provide adequate water quality protection when they were properly implemented, and poor Rule implementation was the most common cause of observed water quality impacts.

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The Monitoring Study Group would like to acknowledge and thank several individuals and companies for their assistance with the Hillslope Monitoring Program. Roger Poff of R.J. Poff and Associates and Cliff Kennedy and Joe Hiss of High Country Forestry displayed great personal interest in the program, worked hard to make the program succeed, helped improve the monitoring protocols, and entered data in the database. All three have provided assistance in developing database queries and have reviewed drafts of this report. Dr. Don Warner, Calif. State Univ., Sacramento, developed the Hillslope Monitoring database and the queries run on the data sets. Don has displayed a high degree of technical competence, as well as patience in dealing with a very large and complex database. In 1996, Gary Rynearson, Jim Hawkins and Lou Tirado of Natural Resources Management Corporation collected the field data in Humboldt County. Chris Hipkin assisted R.J. Poff and Associates with the 1996 field data collection in Mendocino County. Tom Schott and Curtis Ihle representing the Mendocino and Humboldt County Resource Conservation Districts respectively, played significant roles in making the 1996 monitoring projects in their counties successful.

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Chuck Abshear, Norm Cook and Janice Stine queried CDF RBASE databases for a pool of Timber Harvesting Plans from 1996 through 1998 in Santa Rosa, Fresno, and Redding, respectively. Scott Gregory, Student Assistant, entered the 1996 data in the database and completed numerous tasks to make the program run smoothly. Mavis Hotchkiss developed the CDF contracts that allowed the monitoring work to proceed. CDF Forest Practice Program staff members Pete Cafferata and John Munn were responsible for compiling and summarizing information and were the primary authors of the report.

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INTRODUCTION

Difficult questions are increasingly being asked by agency scientists, legislators, and the public about the impacts of current forestry operations on critical downstream beneficial uses of water. Unfortunately, in many cases there has been insufficient scientifically valid data available to answer the types of questions that have been asked. The listing and potential listing of numerous fish and wildlife species under the federal Endangered Species Act (ESA) and the listing of numerous watersheds as impaired waterbodies under Section 303(d) of the Clean Water Act have heightened the need for valid data on impacts to these resources from current timber operations. As a result, monitoring the impacts of forestry practices on water quality and anadromous fish habitat has received a greater degree of emphasis in the 1990's (MacDonald et al. 1991, MacDonald and Smart 1993, Wissmar 1993, Dissmeyer 1994).

In California, the State Board of Forestry and Fire Protection (BOF) and the California Department of Forestry and Fire Protection (CDF) have jointly worked throughout the 1990's to develop and implement a long-term monitoring program which could provide information to decision makers and the public regarding the effectiveness of the current Forest Practice Rules in protecting water quality. The BOF formed the Monitoring Study Group (MSG) in 1989 to develop this long-term program. The long-term monitoring program includes both instream and hillslope components.

The Hillslope Monitoring Program has received the most emphasis to date. Specific objectives of this program include: (1) determining if the Forest Practice Rules (FPRs) affecting water quality are properly implemented—implementation monitoring, and (2) determining if the FPRs affecting water quality are effective in meeting their intent when properly implemented—effectiveness monitoring. These two types of monitoring are necessary for differentiating between water quality problems created by non-compliance with a FPR, versus problems with the forest practice. The goal is to provide information on where, when, and in what situations problems occur under proper implementation (Tuttle 1995).

This report summarizes the results that have been obtained from data collected on 150 Timber Harvesting Plans (THPs) that were evaluated from 1996 through 1998 as part of the Hillslope Monitoring Program. **These are to be considered interim results, as this program is an on-going project that will continue to collect field data. Additionally, only frequency count data is presented--without statistical tests.** As more data are collected and sample sizes become larger, detailed statistical analysis will be performed on the hillslope monitoring data sets.

Other projects have been undertaken in California that provide information regarding impacts from timber operations conducted under the modern (i.e., after 1974) Forest Practice Rules. Readers of this report are encouraged to review results from research projects such as the Caspar Creek watershed studies (Ziemer 1998, Lewis et al. 1998), and the Critical Sites Erosion Study (Durgin et al. 1989, Lewis and Rice 1989, Rice and Lewis 1990).

BACKGROUND INFORMATION

Monitoring forestry practices in California has historically related to protection of water quality. Much less emphasis has been placed on monitoring impacts of logging on terrestrial wildlife species by CDF and the BOF, since the California Department of Fish and Game has had the lead for that type of monitoring. The relationship between monitoring and water quality grew out of CDF and the BOF's desire to have the Forest Practice Rules and Review Process certified as Best Management Practices by the U.S. Environmental Protection Agency (EPA), beginning as early as 1977.

After the passage in 1983 of the modern watercourse protection rules specifying protection based on the beneficial uses of water present, the Forest Practice Rules and Review Process were conditionally certified as meeting Best Management Practices standards for Section 208 of the Clean Water Act by the State Water Resources Control Board (SWRCB). The Water Board required that a monitoring and assessment program be implemented for this certification. Due to lack of sufficient funding for a comprehensive four-year program, a one-year qualitative assessment of forest practices was undertaken in 1986 by a team of four resource professionals (Johnson 1993). The "208 Report" (SWRCB 1987) resulted from this review of 100 Timber Harvesting Plans completed over the entire state. The team found that the Rules generally were effective when properly implemented on terrain that was not overly sensitive. They recommended several changes to the Forest Practice Rules based on their observations.

In 1988, CDF, the Board of Forestry (BOF), and the SWRCB entered into a Management Agency Agreement (MAA) that required the BOF to improve forest practice regulations for better protection of water quality, largely based on the "208 Report". At this point, the SWRCB approved certification. EPA, however, withheld certification until the conditions of the MAA were satisfied, one of which was to develop a long-term monitoring program to determine the effectiveness of the Forest Practice Rules and Review Process in protecting water quality. The BOF formed an interagency task force, later known as the Monitoring Study Group, to develop the long-term monitoring program.

The MSG, working with the consulting firm William Kier Associates, held public outreach meetings throughout the state in 1990 to capture what the public felt was important in a monitoring program. The two biggest concerns expressed by members of the public were the protection of cold water fish habitat and domestic water supplies. They also stated that the monitoring program being developed should be able to detect changes in these beneficial uses resulting from timber operations (CDF 1991). The MSG used the information collected by Kier to write a detailed report for the BOF (BOF 1993). This document stressed the need for both implementation and effectiveness monitoring, as well as the value of a pilot project to develop appropriate techniques for both instream and hillslope monitoring. The Pilot Monitoring Program was completed during 1993 and 1994, and reports documenting the work were written in 1995. The Department of Fish and Game conducted the instream pilot work and documented training and quality control needs for several instream monitoring parameters, as well as the range in variability encountered (Rae 1995).

For the hillslope component of the pilot program, Dr. Andrea Tuttle and CDF modified previously developed U.S. Forest Service hillslope monitoring forms (USFS 1992) to allow detailed information to be recorded for locations within Timber Harvesting Plans (THPs) that were felt to present the greatest risk to water quality--roads, skid trails, landings, crossings and watercourse and lake protection zones (Tuttle 1995). The forms developed for the U.S. Forest Service monitoring program did not adequately identify the specific requirements of the Forest Practice Rules. As a result, these initial forms were either substantially modified (i.e., watercourse crossings and landings) or completely re-written (i.e., transect evaluations were developed for roads, logging operations, and watercourse and lake protection zones). Harvest units were not included because few of the Rules apply to these areas and previous studies had shown that most of the erosion features were associated with the more disturbed sites (Durgin et al. 1989).

The Monitoring Study Group members identified all of the separate Forest Practice Rule requirements that could be related to protection of water quality. This resulted in a list of over 1300 separate items, including plan development, the review process, and field application requirements. This was then pared down to 190 Rule requirements that are implemented during the conduct of a Timber Harvesting Plan and can be evaluated by subsequent field review. Cumulative watershed effects Rules and Rules related to the THP Review process were not included because they could not be evaluated using an on-the-ground inspection of the THP area. Many of the Rules were broken down into separate components to specify the multiple requirements for field evaluations.

The Division of Mines and Geology assisted with the hillslope pilot program and provided detailed geomorphic mapping for two of the watersheds used for the pilot work (Spittler 1995). Pilot Monitoring Program Manager Gaylon Lee of the SWRCB wrote a summary document and recommendations for the long-term program (Lee 1997).

Due to the fact that hillslope monitoring can provide a more immediate, cost effective and direct feedback loop to resource managers on impacts from current timber operations when compared to instream monitoring (particularly channel monitoring which involves coarse sediment parameters) (Reid and Furniss 1999), CDF and BOF chose to place more emphasis on hillslope monitoring for the Long-Term Monitoring Program. A pilot cooperative instream monitoring project is currently in progress in the Garcia River watershed, located in southern Mendocino County (Euphrat et al. 1998).

THP SAMPLE SELECTION

The CDF/BOF long-term monitoring program was officially launched in 1996, with the collection of hillslope monitoring data on 25 randomly selected THPs in both Humboldt and Mendocino Counties. The initial phase of the hillslope monitoring program was conducted on the North Coast with the goal of collecting information from watersheds with coho salmon habitat due to the recent listing of that species. Contracts were developed with the Resource Conservation Districts in each county, who in turn hired Registered Professional Foresters (RPFs) to collect the detailed field data on THPs that had over-wintered for a period of 1 to 4 years. Natural Resources Management Corporation was the contractor hired by the Humboldt County RCD, while R.J. Poff and Associates was hired by the Mendocino County RCD (Figure 1). Stratified random sampling was utilized to select the THPs for the work completed in 1996. Based on erodibility ratings developed for a study completed by CDMG (McKittrick 1994), approximately 50% of the THPs were included in the areas designated as high overall erosion hazard, 35% were included in the moderate category, and 15% were included in the low erosion hazard rating.[1]

The second phase of the hillslope monitoring program—the statewide sample of THPs—was begun in 1997. CDF directly hired a contractor to collect field data on 50 randomly selected plans statewide in both 1997 and 1998. The contractor for these contracts was R.J. Poff and Associates. An RPF and an earth scientist (professional soil scientist, registered geologist or certified erosion and sediment control specialist) were required to participate in the field work. THPs were randomly selected from a state-wide pool and no longer stratified based on the CDMG erodible watershed categories utilized in 1996.

THPs were included in the random selection for 1996 through 1998 if they met the following criteria:

1. The THP had been filed and completed under the Forest Practice Rules adapted by the BOF after October 1991 (when the most recent WLPZ rules were implemented).

2. The plans selected had been through at least one but not more than four winters since logging was completed. The CDF Completion Report for the entire THP must have been signed by a CDF Forest Practice Inspector, and the date used to determine the 1-4 over-wintering periods was the date

[1] This project rated large (e.g., 50,000 ac) watersheds on their inherent erodibility, excluding land use impacts. Variables input into a GIS model included precipitation, slope, and geology. A low, moderate or high rating was assigned to each factor. Numbers were summed to create an ordinal display of relative susceptibility of watersheds to erosion.

supplied by the RPF that indicated when all the logging was completed on the THP.

3. The THP primarily involved wildlands (e.g., it is not a campground or golf course). Also, the THP was not a road-right-of-way-only plan.

4. The THP had significant components of either ground based logging and/or cable yarding systems and was not entirely helicopter logged.

5. The THP had at least 500 continuous feet of a Class I or II watercourse present.

6. The THP was at least 5 acres in size.

7. The THP was not previously sampled.

CDF's RBASE Forest Practice Database was queried from 1996 through 1998 in Santa Rosa, Redding, and Fresno to produce a combined list of potential THPs meeting the completion and acceptance dates (approximately 2,500 THPs were in the population). A randomized list was produced to provide a preliminary set of THPs to evaluate. Individual THP files were reviewed at each of the three locations to determine when the logging was completed, watercourses present, yarding system(s), size, and wildland classification. THPs eliminated from the preliminary list were replaced with the next acceptable THP meeting the above criteria, keeping the original percentages for each CDF Forest Practice District (i.e., Coast, Northern and Southern) established in the original random sort.[2] Statewide sampling, therefore, is very similar to the distribution of THPs CDF receives at each of its three Forest Practice District offices.

Permission for THP access was requested by letter with follow-up telephone calls for those where a response was not received. Where permission was not granted, the next THP on the list was used. Permission for large industrial owners was received for all but one THP. In contrast, approximately 30% of the selected THPs on small, nonindustrial timberlands were excluded from the study because of either an inability to locate the landowner, sale of the parcel, or denial of access. This resulted in the study being weighted toward the industrial timberlands (Table 1).

[2] If this were not done, a much higher percentage of THPs would have been selected from the Coast Forest Practice District, since many more of these plans have the required watercourse length.

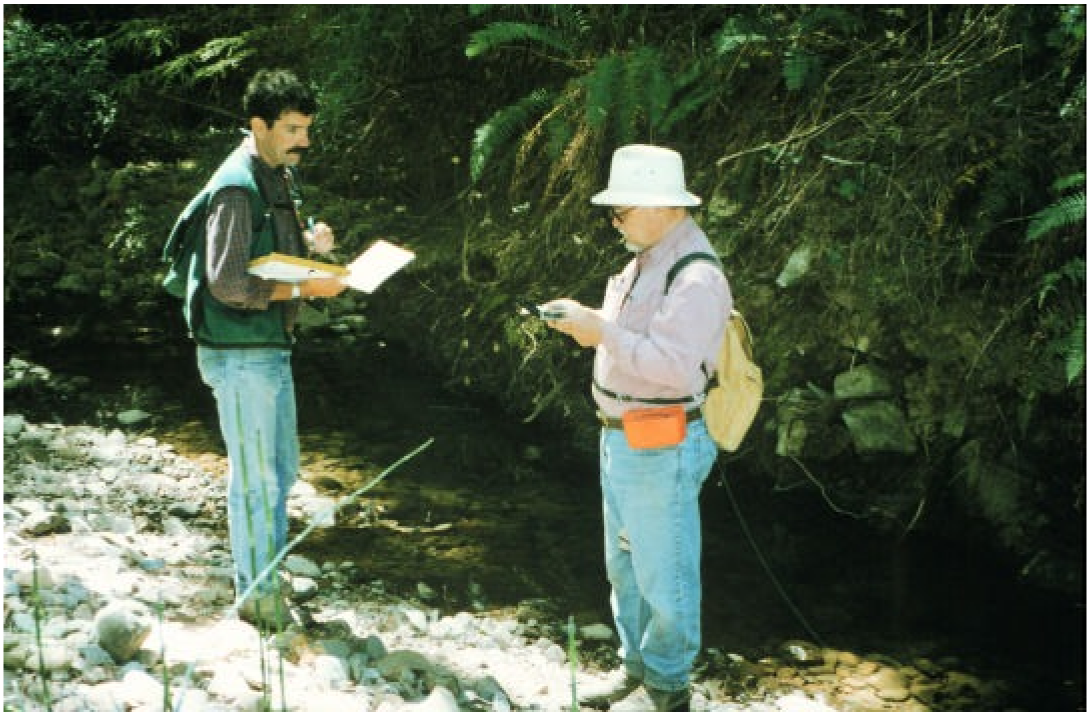

Figure 1. Cliff Kennedy and Roger Poff collecting field data in Mendocino County in 1996.

The THPs sampled from 1996 through 1998 are displayed by Forest Practice District in Table 2 (due to the exclusive sampling in the Coast Forest Practice District in 1996, the sample is disproportionately high for that District). Table 3 displays the distribution of THPs by county.

Table 1. Distribution of THPs by landowner category.

Landowner Category	THPs Selected	THPs Reviewed	Percent Selected	Percent Reviewed
Large industrial timberland owners	76	98	51	65
Small nonindustrial owners/others[3]	74	52	49	35

[3] Other types of landowners include small companies, State Forests, city properties, and water company properties.

Table 2. Distribution of THPs by Forest Practice District.

Forest Practice District	THPs	Percent
Coast	99	66
Northern	33	22
Southern	18	12

Table 3. Distribution of THPs evaluated from 1996 through 1998 by county.

County	North Coast 1996	Statewide 1997-1998	Total Number of THPs
Coast Forest Practice District			
Del Norte		6	6
Humboldt	25	17	42
Mendocino	25	21	46
Trinity		1	1
Sonoma		1	1
Santa Cruz		2	2
Santa Clara		1	1
Northern Forest Practice District			
Shasta		8	8
Butte		4	4
Lassen		2	2
Placer		2	2
Nevada		2	2
Modoc		2	2
Siskiyou		6	6
Trinity		4	4
Glen		1	1
Sierra		1	1
Yuba		1	1
Southern Forest Practice District			
Tuolumne		5	5
Amador		6	6
Calaveras		2	2
El Dorado		3	3
Fresno		2	2
Totals	**50**	**100**	**150**

METHODS

GENERAL INFORMAITON

There are five sample areas to be evaluated within each THP: landings, roads, logging operations (skid trails), watercourse and lake protection zones (WLPZs), and watercourse crossings. All five sample areas are evaluated twice within each selected THP if possible. Additionally, large erosion events are inventoried where they are encountered on the THP.

Conducting the evaluations involves both office and field activity. Office work needed to prepare for the field evaluations includes:

- Reading the THP to identify and become familiar with Review Team requirements, alternatives, in-lieu practices, mitigations, and addenda in the approved plan.

- Filling out "Site Information" sheets for each sample site. These are the top sheets in each packet. Much of this information can be obtained from the THP.

- Lay out road segment grid as described under “Site Selection” below.

SITE SELECTION

Selection of specific sample areas begins with marking approximate 500 foot road segments on all roads on the THP map. Each of these segments is assigned a number. Then a random number table or generator is used to identify one of the segments. From this point, a coin is flipped to determine a direction of travel until a landing is encountered. This randomly selected landing is used for the landing sample. Where more than one road enters or exits the landing, coin flips are used to identify a road transect that begins where the selected road leaves the landing. Coin flips are also used to determine the direction of travel to the first available skid trail transect. Watercourse crossing sites are selected as either the first crossing encountered during the road transect or, if no crossing is encountered, the first crossing along a road selected by coin flip. Finally, the closest approach of a Class I or Class II watercourse is used as the starting point for the WLPZ transect, and direction of travel along the WLPZ is determined by a coin flip. Either GPS readings or topographic maps may be used to record site locations with UTM coordinates.

FIELD ACTIVITIES COMMON TO ALL SAMPLE AREAS

A first step in the field work is to finish filling out Site Information sheets. This is followed by an effectiveness evaluation of pertinent features that present an erosion or water-quality problem, and that permit calculation of the relative proportion of problem to non-problem areas.

Sample area field evaluations are designed to provide a database "sketch" of the sites and transects that are inspected. The resulting detailed information about features is used estimate the proportion of rule or water quality problems in the whole population of similar features. This also allows evaluation of Forest Practice Rule implementation and effectiveness for protection of water quality and identification of problems requiring revisions or additions to the Rules.

At "problem" sites (such as cut bank failures, gullies, excessive grades, and rule violations), the problem type, erosion and sediment delivery site are recorded and a rule implementation evaluation is conducted. Any rills, gullies, or mass failures that are encountered as part of the transect and site inspections are followed to determine whether sediment from these erosional features reached a WLPZ or stream channel. The presence of rills, gullies or deposited sediment at the edge of the high flow or low flow channel is sufficient to class the sediment as having entered that portion of the stream.

After the field review has been completed, an evaluation of all the Rules is conducted based upon the overall frequency of problem sites and rule violations along the transect as a whole. Implementation of the Forest Practice Rules applicable to a given subject area is rated as either exceeding the requirements of the Forest Practice Rules or THP requirements, meeting the requirements, minor departure from requirements, major departure from requirements, not applicable, cannot determine (evidence is masked), or cannot evaluate (supply reason).

Major departures were assigned when sediment was delivered to watercourses, or when there was a substantial departure from Rule requirements (e.g., no or few waterbars installed for entire transect). Minor departures were assigned for slight Rule departures where there was no evidence that sediment was delivered to watercourses (e.g., WLPZ width slightly less than that specified by the Rule).[4]

[4] Minor and major departures from Rule/THP requirements have similar impact to water quality for watercourse crossings since sediment is assumed to enter the watercourse for both categories.

ROAD AND SKID TRAIL TRANSECT METHODS

Transects

The transect starting point is located using procedures described under Site Selection. Roads or skid trails that were not used as part of the THP being evaluated are not included. The starting point for the road or skid trail transect is the point at which it narrows to its "normal width" and is outside of the influence of operations on the landing. Where a road forks, the transect follows the road that is of the same general type of construction and level of use. Where a skid trail forks, the branch that continues in the same basic direction (up-hill or down-hill) as the transect to that point is followed. If there are no clear differences, a coin flip is used to determine direction. The direction that was chosen is described in the comments section to provide a record for follow-up inspections or re-measurement.

At the start of a transect, a measurement string is tied to a secure object, the string box counter is set to zero, and the location of the starting point is described in the comments for future reference. The road or trail is walked in the pre-determined transect direction for a distance of 1000 feet or to the end, whichever occurs first.[5]

If the total road distance is less than 800 feet, another transect on a different road segment is started from the landing without resetting the string box counter, and measurements are continued to get a total transect length of 1000 feet.

The minimum skid trail transect length is 500 feet. If needed, this distance can be made up of several segments. Skid trails are randomly selected from those entering the landing if possible. If a skid trail is not available at this location, the nearest trail that brought logs to the measured road segment is used. Skid trail transects are no shorter than the length of trail requiring two waterbars. If the total skid trail distance is less than 300 feet, the transect is continued from the most recently passed trail intersection. Where there has been no intersection, the transect is continued from the landing without resetting the string box counter, and the transect is continued in this fashion up to a maximum of 1000 feet. If there is less than 500 feet of skid trail, the available trail length is sampled and an explanatory comment is included. If there are no skid trials, this is noted at the start of one of the logging operations forms.

[5] Note that main-line logging roads were not sampled if drainage structures had been removed to facilitate log hauling from more recent timber operations. This type of road (i.e., native surfaced primary road with waterbars) was under sampled due to this problem.

Data Recording

The general procedure for linear transects is to record the starting and ending distance to each feature as it is encountered. On roads, for example, the beginning and ending point of all features (e.g., inside ditches, cut banks, location of waterbreaks, cross drains, etc.) are recorded, regardless of whether or not they present a water quality problem. Consecutive numbers are assigned to each feature, which, in combination with the THP and transect numbers, becomes a unique database identifier for that feature. Then codes are entered to indicate the type of feature and any associated drainage problems, erosion causes, and sediment production, plus information about road or trail gradient, sideslope steepness, and dimensions of erosion features.

LANDING METHODS

Site Identification

The landing to be evaluated is located as previously described under Site Selection. Landing selection is important because it becomes the basis for locating random sites for the other sample areas.

Landing Surface

The entire landing surface is inspected for rills and gullies. Gullies are defined as being 6" or greater in depth and of any length. The total length of all gullies and their average width and depth is recorded on the data forms. Sample points for rills were located along a single transect that bisects the landing into two roughly equal parts perpendicular to the general direction of surface runoff in 1996. The percentage of the landing surface drained by rills was estimated for 1997-1998. To be counted, rills had to be a least one inch deep and 10 feet long. Both rills and gullies are inspected to determine whether they continue for more than 20 ft. past the toe of the landing fill slope, and gullies are followed to determine if sediment has been delivered to the nearest WLPZ and channel.

Cut Slopes (if present)

The face of the cut slope is inspected for evidence of slope failures, rilling and gullying. The path of any transported sediment is traced to determine the quantity and whether material is transported to drainage structure(s) on the landing.

Fill Slopes (if present)

The toe of the fill slope is inspected for evidence of slope failures, rilling and gullying. Rills or gullies that are not caused by drainage from the landing surface are traced to determine whether they extend to a downslope channel. All slope failures are evaluated to determine the total amount of material moved and whether the material moved reaches a stream channel.

WATERCOURSE CROSSING METHODS

Site Identification

A watercourse crossing site is established at the first crossing encountered in the road or skid trail transects, and is noted as a feature on the transect. If no crossing is encountered as part of the transects, the first crossing beyond the end of the road transect is used for this evaluation.

Once the crossing has been identified, the next step is to determine the length of road to be included. This is done by walking in both directions from the crossing and identifying the points where runoff from the road surface, cuts, and fills no longer carries toward the stream crossing. The road length for evaluation also includes the cut-off waterbar that should route water away from the crossing.

Fill Slopes

The crossing fill slope is evaluated to determine whether it has vigorous dense cover or if at least 50% of its surface is protected by vegetation, mulch, rock, or other stable material. The presence and frequency of rills, gullies and cracks or other indicators of slope failure are noted, and the size of rills and slope failures is recorded.

Road Surface

The type and condition of road surfacing is assessed and is evaluated for ruts from vehicles and, if ruts are present, whether they impair road drainage. The presence, frequency and length of rills and gullies on the road surface are also determined along with average gully size and surface drainage conditions. The presence, condition, and effectiveness of cutoff waterbars and inside ditches is evaluated along with evidence of ponding or other water accumulation on the road.

Culverts

The stream channel at both the culvert inlet and outlet is examined for evidence of scouring. The potential for plugging at the upstream inlet is assessed along with the diversion potential in case the culvert does become plugged. Alignment of the culvert, crushing of the inlet and outlet, and degree of corrosion are also evaluated. Pipe length and gradient are determined and evidence of piping around the culvert is identified.

Non-Culvert Crossings (e.g., Rocked Class III crossings)

The crossing is examined to determine the type and condition of armoring and whether downcutting or scouring at the outlet is occurring. Crossing approaches are evaluated to determine if they have been maintained to prevent diversion of stream overflow down the road should the drainage structure become plugged.

Removed or Abandoned Crossings (where applicable)

Removed crossings are examined to determine whether the restored channel configuration is wider than the natural channel and as close as feasible to the natural watercourse grade and orientation. The location of excavated material and any resulting cut bank are assessed to determine if they are sloped back from the channel and stabilized to prevent slumping and minimize erosion. The crossing is also evaluated for the following conditions:

- Permanent, maintenance free drainage.
- Minimizing concentration of runoff, soil erosion and slope instability.
- Stabilization of exposed soil on cuts, fills or sidecast that prevents transport of deleterious quantities of eroded surface soils to a watercourse.
- Grading or shaping of road surfaces to provide dispersal of water flow.
- Pulling or shaping of fills or sidecast to prevent discharge of materials into watercourses due to failures of cuts, fills or sidecast.

WLPZ TRANSECT METHODS

Transects

Two WLPZs are sampled on each THP, when available (transects may be shorter than 1000 feet, but must be at least 500 feet to be included). These WLPZ segments are located along the nearest, accessible Class I or II watercourse relative to the selected landing sites. When WLPZs are present near only one of the selected landings, both segments are selected from this location. And where there is only one WLPZ on the THP, both segments may be located along the same watercourse but, where possible, should represent different conditions (e.g., different stream classes, stream gradients, sideslope gradients, adjacent logging methods, etc.).

For Class I waters, two 1000 foot long transects are sampled parallel to the stream within the WLPZ. One of these is a "mid-zone" transect located between the watercourse bank and the up-slope boundary of the WLPZ. The other is a "streambank" transect located immediately along the stream bank and parallel to the mid-zone transect. For Class II watercourses, only the mid-zone transect is used.

Data Recording

Within the transects, groundcover and canopy cover are evaluated at regular intervals and at disturbed sites where timber operations have exposed more than 800 continuous square feet of mineral soil. Several other factors are also evaluated wherever they occur, such as sediment delivery to the channel, streambank disturbance, and channel conditions.

Parameters estimated in the mid-zone transect include groundcover at every 100 feet, canopy cover at every 200 feet, WLPZ width at every 200 feet (concurrent with canopy measurement) and whenever there is a change in sideslope class, and sediment to the channel wherever it occurs. Measurements in the Class I watercourse streambank transect include canopy cover at 200 foot intervals, disturbance to streambanks wherever it occurs, and other stream related features. In addition, rule implementation is evaluated continuously along both transects, and any rule requirements or discrepancies are noted as a feature and are included in the implementation evaluation.

The general procedure for recording WLPZ transect data and the use of codes is similar in format to the methods used for roads and skid trails, but with features that are specific to WLPZ conditions and rule requirements. As with roads, the starting and ending distance to each feature is recorded along with a unique identification number and information about feature type, erosion causes, dimensions of erosion features, and sediment deposition.

Groundcover is estimated in an area with a diameter of approximately one foot located directly in front of the observer's boot toe, where adequate cover is defined as "living plants, stumps, slash, litter, humus, and surface gravel (minimum diameter of 3/4 inch) in amounts sufficient to break the impact of raindrops and serve as a filter media for overland flow." To date, canopy cover has been measured using a spherical densiometer (Figure 2). However, future measurements will be made using sighting tube transects with randomly located starting points to reduce the potential for bias resulting from overstory conditions in areas adjoining the measurement site (Robards et al. 1999) (Figure 3).

Features do not need to intersect the transect line to be included. This is necessary because dense vegetation and other obstructions in WLPZs make a straight line transect impractical to accomplish, so the location of the transect line will be biased by access within the WLPZ, and some extensive WLPZ features may not intersect the transect, as would be the case with a road running parallel to, but not on, the transect. In cases of steep terrain and limited visibility, identifying features at a distance from the transect line is benefited by the assistance of a second person who is not limited by the string box and can move about within the WLPZ.

The WLPZ measurements begin at one end of the mid-zone transect and include a continuous record of the beginning and end points of features encountered along the transect for a distance of 1000 feet. The streamside transect begins at a point perpendicular to the end of the mid-zone transect and proceeds in the opposite direction toward the starting point of the mid-zone transect.

LARGE EROSION EVENT EVALUATION METHODS

Erosion events with voids larger than 100 cubic yards are assessed whenever they are encountered on the THP. For watercourse crossings that have failed, a large erosion event is defined as greater than 10 cubic yards. These sites may be identified during the standard site evaluations, while traveling within the THP, or as a result of information provided by landowners or managers. Information collected includes the location, size, and type of feature, and an evaluation of the causal connections between the feature and specific timber operations, along with any applicable Forest Practice Rules.

If more than five large erosion events are discovered on a THP, only the first five are required to be completely evaluated by the field team. For additional events, only the location, type, and estimate of the cause are briefly noted.

DATABASE DEVELOPMENT

The Hillslope Monitoring Database was developed in Microsoft Access for Windows (Microsoft Office 97) and runs on a personal computer. It is a relational database, approximately 30 megabytes in size, and flexible enough to accommodate monitoring form changes. A preliminary set of queries has been developed that is the basis for the results presented in this report. Future queries and sorts will provide more information on Forest Practice Rule implementation and effectiveness. As an example, queries are planned to provide information about how geologic type affects the frequency of erosion events on road transects.

Figure 2. Concave spherical densiometer with the Strickler (1959) modification.

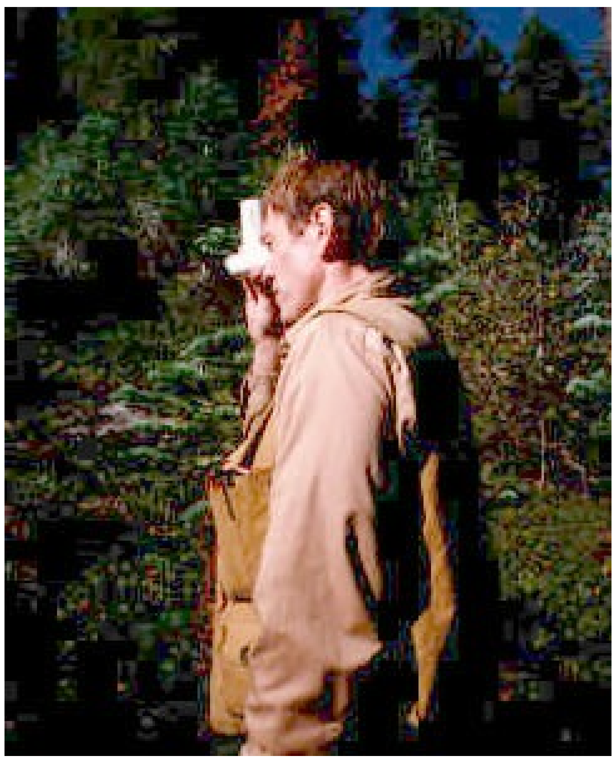

Figure 3. Sighting tube use for unbiased estimate of canopy cover.

RESULTS

The results of the hillslope monitoring conducted to date are summarized by major category: roads, logging operations, landings, watercourse crossings, watercourse and lake protection zones, and large erosion events. The data that are presented are frequency counts; detailed statistical tests have not been run to date. Statistical tests that involve categorical data, such as the implementation data, will require large sample sizes which generally are not available at this time (Lewis and Baldwin 1997). Future reports on the Hillslope Monitoring data will include the results of statistical tests when sample sizes are appropriate.

ROADS

From 1996 through 1998, 292 randomly located road transects were evaluated, for a total of 279,150 feet (52.87 mi.). Approximately 81% of the road transects were classified as seasonal, 12% as permanent, 5% as temporary, and 2% as a combination of road types. About 29% of the road length reviewed had been surfaced with rock.

Upon completing the evaluation of the randomly located 1000 foot road transect, the field team rated the overall implementation of specific Forest Practice Rules that relate to roads and water quality (Table A-1). A total of 59 questions were answered in the field based on 46 Forest Practice Rules, since some Rules were broken down into separate components. Most of the Forest Practice Rules evaluated on road transects had high percentages (i.e., greater than 90%) of cases where implementation ratings either met or exceeded the standard Rule. For Forest Practice Rules where the sample size was adequate [6], 22 Rule requirements were found to have combined minor and major departures greater than 5% (Table 4). However, the majority of the implementation ratings that triggered Rules to be displayed in Table 4 were for minor departures from Rule requirements.

The Rules with the highest numbers of departures were related to waterbreak spacing, maintenance, and construction standards; adequate number, size,

[6] For all categories (i.e., roads, skid trails, landings, watercourse crossings, and WLPZs), there had to have been at least **30** observations where field team assigned an implementation rating of exceeded rule requirement, met requirement, minor departure from requirement, or major departure from requirement. Thirty observations represents 10% or more of the implementation ratings in all cases.

Table 4. Road related Forest Practice Rule requirements with more than 5% departures based on at least 30 observations where implementation could be rated (note that some Rules are broken into component requirements, table is ordered by total departures).[7]

Forest Practice Rule	Description	Minor Departure (%)	Major Departure (%)
914.6(c)	Waterbreak spacing according to standards	20.1	2.7
923.1(f)	Adequate numbers of drainage facilities provided to minimize erosion	16.7	3.1
923.4(c)	Waterbreaks maintained to minimize erosion	16.7	2.7
923.2(h)	Drainage structures of sufficient size, number and location to carry runoff water	13.9	3.2
923.2(h)	Drainage structures of sufficient size, number and location to minimize erosion	14.4	2.5
923.2(b)	Sidecast minimized for slopes>65% for distances >100 feet	16.7	0
914.6(g)	Waterbreaks have an embankment of at least 6 inches	12.1	1.4
923.2(o)	Discharge onto erodible fill prevented	10.4	1.9
914.6(f)	Waterbreaks installed to discharge into cover	12.3	0
923.1(a)	If landing on road >1/4 ac or required substantial excavation-shown on map	7.3	4.8
914.6(g)	Waterbreaks constructed with a depth of at least 6 inches cut into firm roadbed	11.0	0.9
923.2(p)	Waterbreaks installed according to standards in 914.6	9.4	1.0
923.1(d)	For slopes >65% or 50% within 100 ft of WLPZ, soil treated to minimize erosion	8.2	2.0
914.6 (f)	Where waterbreaks don't work--other erosion controls	7.0	0.9
923.4 (j)	Drainage ditches maintained to allow flow of water	7.3	0
923.2 (d) C	Fills constructed with insloping approaches, etc.	6.1	1.2
923.2 (d) N	Breaks in grade above/below throughfill	7.0	0
923.6	Wet spots rocked or otherwise treated	6.7	0
923.1 (a)	Road shown on THP map correctly	5.6	0.3
923.4 (c)	Erosion controls maintained during maintenance period	5.9	0
923.2(l)	Trash racks, etc. installed where appropriate	5.6	0
923.2 (m)	Sidecast extending >20 ft treated to avoid erosion	2.6	2.6

[7]Major departures were assigned when sediment was delivered to watercourses, or when there was a substantial departure from Rule requirements (e.g., no or few waterbars installed for entire transect). Minor departures were assigned for slight Rule departures where there was no evidence that sediment was delivered to watercourses (e.g., WLPZ width slightly less than that specified by the Rule).

and the location of drainage structures to minimize erosion; prevention of discharge onto erodible fill; and sidecast limitations on steep slopes. Erosion problem points (i.e., rills, gullies, cutbank or sidecast sloughing, mass failures) were described on the road transects where they were encountered. A total of 727 erosion problem points associated with the sampled THPs were noted. While some road transects had no erosion problem points, the overall average equated to one problem point for every 380 feet of road. The distribution of erosion features associated with current Timber Harvesting Plans are summarized in Table 5. Total erosion volumes from cutbank/sidecast sloughing, mass failures, and gullying were approximately 1990, 3010, and 1050 yds^3, respectively.[8] These estimates are the volumes of voids remaining at hillslope locations, not the amount of sediment delivered to watercourse channels. When a problem point was discovered, implementation of the appropriate Forest Practice Rule(s) was also rated. A total of 41 Rule requirements were rated for implementation at erosion problem points along road transects. Of these, 13 were responsible for approximately 90% of the problem points associated with roads (Table 6).

Table 5. Erosion features found on road transects created by the current THP.

Erosion Feature	Number of Features
Cutbank/sidecast sloughing	80
Mass Failure	18
Gullying	148
Rilling	478
Other Erosion Features	3

From Table 6, it is clear that the vast majority of the problem points noted along the road transects were judged to be due to either minor or major departures from specific Forest Practice Rule requirements. When considering all the implementation ratings assigned at erosion problem points encountered, only 3.1% were associated with situations where the Forest Practice Rule requirements were judged to have been met or exceeded and 96.9% were associated with minor or major departures from the Rule requirements. In other

[8] Note that rilling volumes were not determined. Erosion from rilling is generally a much smaller component when compared to that from mass wasting and gullying. For example, Rice et al. (1979) found that rilling accounted for only 3% of total hillslope erosion following tractor logging in the South Fork Caspar Creek watershed. Other volumes listed are to be considered preliminary data. Only when lengths, depths, and widths were all greater than 1 foot were volumes calculated to make these estimates. Additionally, all the width, depth and length data were rounded to the nearest integer. Efforts are now underway to revise these calculations and use the one-tenth foot values available for width and depth estimates.

Table 6. Forest Practice Rules that account for approximately 90% of all the Rule requirements rated for implementation at erosion problem points along road transects.

Forest Practice Rule	# of Times FPR Cited	Description of Rules Rated for Implementation where Problems Occurred	Exceeds/ Met Rule (%)	Minor (%)	Major (%)
923.1(f)	254	Adequate number of drainage facilities to minimize erosion	4.7	83.9	11.4
923.2(h)	240	Drainage structures of sufficient size, number and location to minimize erosion	7.9	78.3	13.8
923.2(h)	226	Drainage structures of sufficient size, number and location to carry runoff water	0.4	86.7	12.8
914.6(c)	195	Waterbreak spacing according to standards	6.2	80.0	13.8
923.4(c)	134	Waterbreaks maintained to minimize erosion	0	69.4	30.6
914.6(f)	125	Waterbreaks discharge into cover	0	98.4	1.6
923.2(o)	119	Discharge onto erodible fill prevented	0	95.8	4.2
914.6(g)	71	Waterbreaks have embankment of at least 6 inches	0	77.5	22.5
914.6(g)	61	Waterbreaks cut to depth of 6 inches	0	73.8	26.2
923.2(p)	51	Waterbreaks installed according to 914.6	11.8	66.7	21.6
914.6(f)	28	Where waterbreaks are not effective, other erosion controls installed as needed	0	89.3	10.7
923.4(i)	25	Soil stabilization treatments installed on cuts, fills, or sidecast to minimize surface erosion	4.0	88.0	8.0
923.4(j)	19	Drainage ditches maintained to allow free flow of water	15.8	84.2	0

words, nearly all of the problems resulted from non-compliance. For a small percentage of the problem points, even though properly implemented, the Rule(s) still resulted in erosion problems.[9]

Table 7 displays the counts of road drainage structures inventoried with and without problem points. From the total population of waterbreaks evaluated, approximately 10% did not conform to the requirements of the Rules. Rolling dips and culverted cross drains had deficiencies 7% and 5% of the time, respectively. Note that multiple types of Rule requirement violations are possible at each drainage structure with a problem. Therefore the sum of drainage structures with problems will be less than the counts for major and minor Rule departures.

[9] Lewis and Baldwin (1997) suggested in their statistical review of this project that implementation would have to be rated immediately following the completion of logging and prior to stressing storm events to remove observer bias. That is, it is likely that some percentage of the problem points might not have been classed as Rule departures if they had been evaluated at the end of timber operations. The percentage of departures for which this is true is unknown. CDF's Modified Completion Report will provide information on implementation following harvesting that may help us address this problem.

Table 7. Counts of drainage structures evaluated along road transects with and without problems.

Drainage Structure Type	Total Number	Count–No Problem	Count—Problem	% with Problems
Waterbreaks	1,055	957	98	9.3
Rolling Dips	271	251	20	7.4
Leadoff Ditch	138	136	2	1.5
Culvert cross drain	137	130	7	5.1
Other drainage structure	38	37	1	2.6

Information recorded during the road transect evaluations allows us to determine the source, cause, and depositional area associated with the erosion features. Table 8 displays the different types of erosion and percentages of features associated with varying types of source areas. Cutbank and sidecast sloughing came predominantly from road cutbanks, with a lesser component from fill slopes. Mass failures were associated mostly with fill slopes, with much smaller components from cutslopes and hillslopes above the road. Gullying was more equally distributed through all the source codes, but the major sources were waterbar outlets, fill slopes, and road surfaces, respectively. Rilling, in contrast, was nearly always associated with the road surface.

Erosion cause codes are displayed in Table 9.[10] Most of the observed cutbank and sidecast sloughing was associated with cut slopes that were judged to be either too steep or too tall. Other frequently cited codes for contributing causes

Table 8. Number (and percentage) of the source location of the recorded erosion features for road transects (note that multiple source codes can be assigned to single erosion features).

Source	Sloughing	Mass Failure	Gullying	Rilling
Cut Slope	38 (70.4)	2 (11.8)	4 (2.7)	5 (1.1)
Fill Slope	9 (16.7)	12 (70.6)	30 (20.0)	15 (3.2)
Road Surface	1 (1.9)	1 (5.9)	24 (16.0)	388 (83.6)
Hillslope Above Road	4 (7.4)	2 (11.8)	6 (4.0)	7 (1.5)
Hillslope Below Road	1 (1.9)	0	0	0
Inside Ditch	0	0	14 (9.3)	6 (1.3)
Rolling Dip Outlet	0	0	10 (6.7)	1 (0.2)
Waterbar Outlet	1 (1.9)	0	54 (36.0)	35 (7.5)
Waterbar Ditch	0	0	4 (2.7)	3 (0.6)
Rolling Dip Ditch	0	0	2 (1.3)	1 (0.2)
Other	0	0	2 (1.3)	2 (0.6)
Total	54 (100)	17 (100)	150 (100)	464 (100)

[10] Note that more than one cause code could be recorded for an erosion event.

were steep side slopes, unstable fill, and highly erodible surface material. Unstable slopes, steep side slopes, and unstable terrain were the most commonly cited cause codes associated with mass failures. More than three-quarters of the observed gullying was coded as being associated with drainage feature problems. Approximately 10% of the time, highly erodible surface material was also listed as a cause of the observed gully. Finally, over 60% of the rilling was associated with drainage feature problems, with highly erodible surface material and steep road gradient being less frequently cited cause codes.

Because drainage feature problems were the most commonly cited cause for gullying and rilling, additional detail for this category is displayed in Table 10. For gullying, spacing of drainage structures (judged to be too wide) was the most frequently cited problem, closely followed by cover (drainage structure did not discharge into vegetation, duff, slash, rocks, etc.). Inappropriate location of the drainage structure was the third most frequently cited drainage problem. The results for rilling are similar to those for gullying. Spacing of drainage structures was cited over 70% of the time when rilling was encountered, with cover being recorded about 8% of the time. Drainage feature problems were often not cited as being associated with mass failures. When they were, shotgun outlets without armoring, plugged culvert inlets, cover, and maintenance were the most frequently cited problems. Similarly, sloughing was usually not associated with drainage feature problems, as illustrated by the fact that the most commonly cited drainage feature problem was the "other" category.

Table 9. Number (and percentage) of recorded erosion cause codes that contributed substantially to development of recorded erosion features on road transects (note that multiple cause codes can be assigned to a single erosion feature).

Cause	Sloughing	Mass Failure	Gullying	Rilling
Drainage feature problem	2 (2.6)	4 (10.8)	124 (76.5)	322 (61.1)
Highly erosive surface	8 (10.5)	3 (8.1)	16 (9.9)	95 (18.0)
Other	4 (5.3)	4 (10.8)	8 (4.9)	12 (2.3)
Steep road gradient	0	0	5 (3.1)	51 (9.7)
Unstable fill	9 (11.8)	10 (27.0)	4 (2.5)	0
Rutting	0	0	3 (1.9)	27 (5.1)
Steep side slopes	11 (14.5)	8 (21.6)	1 (0.6)	15 (2.8)
Unstable terrain	7 (9.2)	6 (16.2)	1 (0.6)	1 (0.2)
Cut slope too long	1 (1.3)	0	0	1 (0.2)
Cut slope too steep	16 (21.1)	1 (2.7)	0	1 (0.2)
Cut slope too tall	18 (23.7)	1 (2.7)	0	2 (0.4)
Total	76 (100)	37 (100)	162 (100)	527 (100)

The location of sediment deposition resulting from these various types of erosion features is of critical concern when addressing protection of beneficial uses of water. Figure 3 displays the sediment deposition categories for the various types of erosion features previously described above. Only 6% of the sloughing features were found to have transported sediment to the channel; another 3% had material transported into the WLPZ. For gullying, about 18% of features had sediment transported into the channel, with another 3% deposited in the WLPZ. Mass wasting resulted in sediment transported into the channel 47% of the time, and material entering the WLPZ an additional 3% of the time. Finally, rilling features had sediment deposited in channels 13% of the time, with an additional 3% deposited in the WLPZ.

Table 10. Number (and percentage) of drainage feature problems associated with erosion features on road transects (note that multiple drainage feature codes can be assigned to a single erosion feature).

Drainage Feature Problem	Sloughing	Mass Failure	Gullying	Rilling
Spacing	1 (10)	0	73 (36.0)	342 (70.5)
Cover	2 (20)	1 (20)	67 (33.0)	39 (8.0)
Location Inappropriate	0	0	26 (12.8)	16 (3.3)
Divert	0	0	10 (4.9)	32 (6.6)
Maintenance	0	1 (20)	7 (3.4)	33 (6.8)
Flow	0	0	7 (3.4)	7 (1.4)
Other	4 (40)	0	5 (2.5)	5 (1.0)
Rolling dip break	0	0	3 (1.5)	4 (0.8)
Shotgun outlet w/out armoring	1 (10)	2 (40)	2 (1.0)	0
Runoff escaped	0	0	2 (1.0)	2 (0.4)
Blocked ditch	2 (20)	0	1 (0.5)	2 (0.4)
Plugged inlet	0	1 (20)	0	0
Height	0	0	0	3 (0.6)
Total	10 (100)	5 (100)	203 (100)	485 (100)

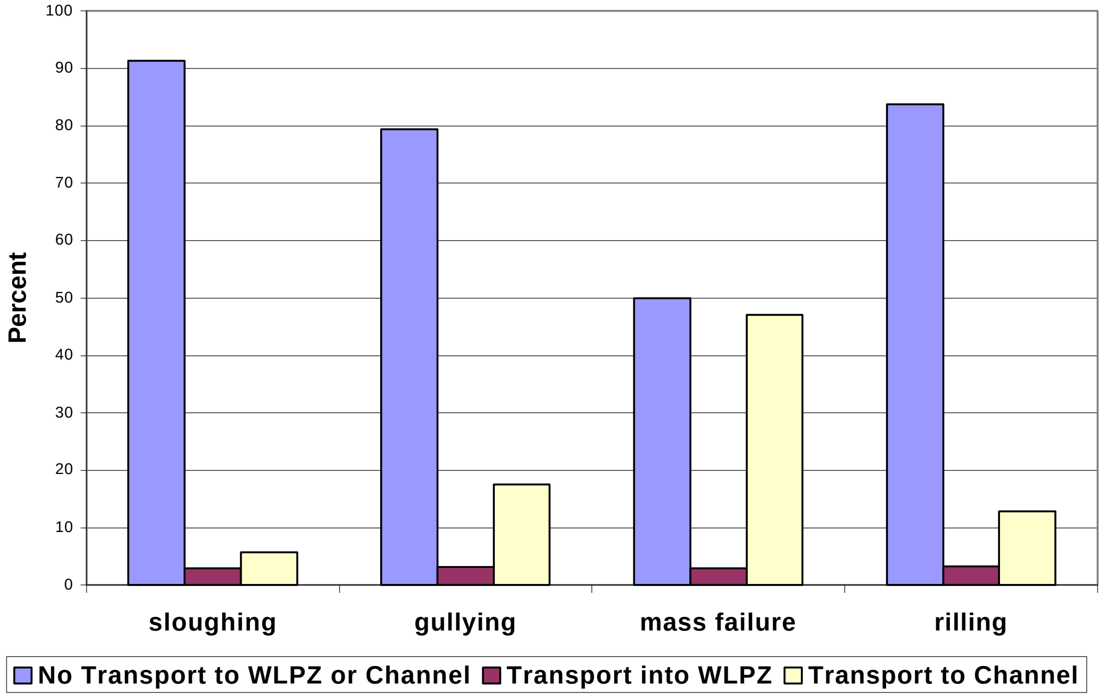

Figure 4. Sediment deposition sites for erosion features produced from current THPs and associated with road transects (percent of the number of occurrences for each feature type).

Logging Operations (Skid Trail Transects)

The logging operations component of the hillslope monitoring program sampled 246 randomly located skid trail transects, for a total of 173,976 feet (32.95 mi.). For THPs that had been yarded exclusively with cable systems, this portion of the field work was omitted. Field procedures and forms are similar for both roads and logging operations—except that implementation ratings are assigned for Forest Practice Rules relating to ground skidding operations and the site information recorded is somewhat different. Therefore, results will be presented in a similar manner.

Overall implementation ratings of the Forest Practice Rules relating to logging operations on skid trail transects are displayed in Table A-2. A total of 26 questions were developed from 22 Forest Practice Rules. Table 11 shows that for Rule requirements with at least 30 observations, three Rules were found to have more than 5% major and minor departures. The highest percentage of departures from Forest Practice Rule requirements were for Rules specifying the installation of other erosion control structures where waterbreaks cannot disperse runoff, waterbreak spacing, and waterbreak maintenance.

Table 11. Skid trail related Forest Practice Rule requirements with more than 5% departures based on at least 30 observations where implementation could be rated (note that table is ordered by total departures).

Forest Practice Rule	Description	Minor Departure (%)	Major Departure (%)
914.6 (f)	Where waterbreaks cannot disperse runoff, other erosion controls installed as needed	19.7	3.9
914.6(c)	Waterbreak spacing equals standards	11.0	4.7
923.4 (c)	Waterbreak maintained to divert runoff water	7.1	0.4

Problem points were described along skid roads where they were observed by the field team. A total of 148 erosion problem points were recorded that could be attributed to the current THP, equating to an average of one problem point for every 1,175 feet of skid trail evaluated. Eight Forest Practice Rule requirements were associated with significant numbers of erosion problem points (Table 12). All of the problem points encountered along skid trails were judged to be due to either minor or major departures from specific Forest Practice Rule requirements. The total count of waterbreaks along skid trail transects was 1,614. Sixty-four of these waterbreaks were inventoried as problem points that did not conform to the requirements of the Rules. This equates to approximately 4% of all waterbreaks.

Erosion features associated with current Timber Harvesting Plans are summarized in Table 13. Gullying, rilling, and mass failures were recorded in roughly the same percentages as were recorded for the road transects--but much less frequently. Total erosion volumes for gullying, mass failure, and cutbank/sideslope sloughing were approximately 200, 1070, and 5 yds^3, respectively.[8] These estimates are the volumes of voids remaining at hillslope locations, not the amount of sediment delivered to watercourse channels.

Table 12. Forest Practice Rules that account for approximately 90% of all the Rules rated for implementation at problem points along skid trail transects.

Forest Practice Rule	# of Times FPR Cited	Description of Rules Rated for Implementation where Problems Occurred	Exceeds/ Met Rule (%)	Minor (%)	Major (%)
914.6(c)	68	Waterbreak spacing equal standards	0	85.3	14.7
914.6(f)	37	Waterbreaks discharge into cover	0	100	0
914.6(f)	29	If waterbreaks inappropriate—other structures installed to minimize erosion	0	89.7	10.3
923.4(c)	28	Waterbreaks maintained to divert runoff	0	100	0
914.6(f)	28	Waterbreaks built for unrestricted discharge at lower end	0	100	0
914.6(g)	23	Waterbreaks installed diagonally	0	100	0
914.6(g)	23	Waterbreaks have embankments 6 in high	0	87.0	13.0
914.6(f)	20	Waterbreaks installed to spread runoff water to minimize erosion	0	90.0	10.0

As with the road evaluations, information recorded along the skid trail transects included the source, cause, and deposition associated with these erosion features. Cutbank and sidecast sloughing originated entirely from cut slopes, while 95% of skid trail rilling was associated with the skid trail surface. Mass failures were mostly from cut and fill slopes. Greater than 70% of the gully erosion was associated with the skid trail surface, of which 20% was related to waterbar outlets.

Table 13. Erosion features created by the current THP found on skid trails.

Erosion Feature	Number of Features
Gullying	35
Mass Failure	6
Cutbank/Sidecast Sloughing	3
Rilling	104

Erosion cause codes are displayed in Table 14. Approximately 60% of the rilling was associated with drainage feature problems, with highly erosive surface material (21%) and steep trail gradients (10%) also being cited frequently. Similarly, 60% of the gullying was caused by drainage feature problems, with steep trail gradient (12%) and highly erosive surface material (12%) also cited. About 40% of the mass failures on skid trails were judged to be caused by unstable terrain, with unstable fill and steep side slopes also mentioned.

The most frequently cited drainage feature problems for rilling were spacing of waterbreaks (68%), incomplete diversion of water by waterbreaks (12%), and inappropriate location (11%). For gullying, spacing was recorded 58% of the time, with inappropriate location (16%) and lack of discharge into cover (11%) cited frequently as well.

Table 14. Number (and percentage) of erosion cause codes that contributed substantially to development of recorded erosion features on skid trail transects (note that multiple cause codes can be assigned to a single erosion feature).

Cause	Sloughing	Gullying	Mass Failure	Rilling
Drainage feature problem	0	25 (59.5)	0	64 (60.4)
Highly erosive surface material	1 (33.3)	5 (11.9)	1 (8.3)	22 (20.8)
Steep trail gradient	0	5 (11.9)	0	11 (10.4)
Steep side slopes	1 (33.3)	2 (4.8)	2 (16.7)	2 (1.9)
Other	0	2 (4.8)	1 (8.3)	5 (4.7)
Unstable fill	0	2 (4.8)	3 (25)	1 (0.9)
Organic matter in fill	0	1 (2.4)	0	0
Cut slope too steep	1 (33.3)	0	0	0
Unstable terrain	0	0	5 (41.7)	0
Rutting	0	0	0	1 (0.9)
Total	3 (100)	42 (100)	12 (100)	106 (100)

Figure 4 shows the frequency of sediment deposition sites for rilling and gullying. Sloughing and mass failures are not included because of the small number of occurrences. Approximately 4% of the rills deposited sediment into watercourses; another 4% deposited material into the WLPZ.[11] For gullying, 26% deposited material into channels, with another 5% depositing material into the WLPZ.

[11] Euphrat (1992) documented little transport of sediment to watercourse channels from skid trails in the Mokelumne River watershed.

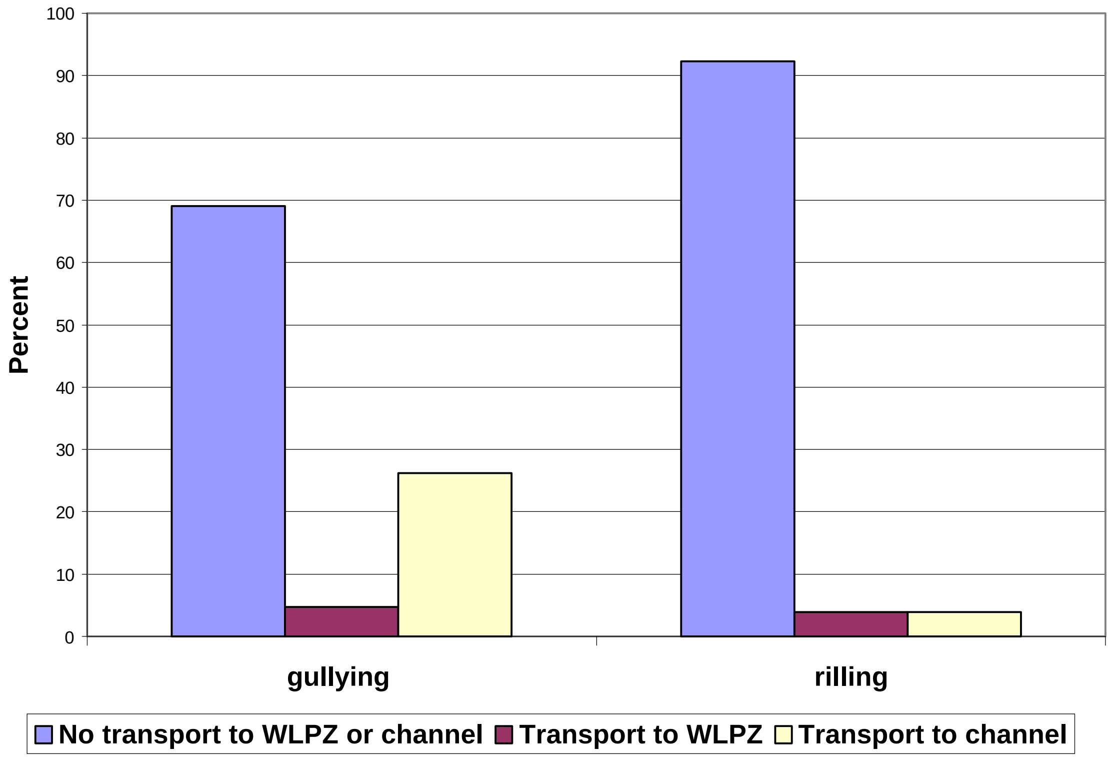

Figure 5. Sediment deposition sites for rilling and gullying produced from current THPs and associated with skid trail transects.

Landings

A total of 291 landings were evaluated as part of the Hillslope Monitoring Program from 1996 through 1998. Approximately 53% of the landings were more than 300 feet from the nearest watercourse receiving drainage off the landing, and 85% were more than 100 feet away. About 87% were constructed on slopes less than 45%, and 48% were built on slopes less than 30%. The landings evaluated were constructed on the "nose of a ridge", above a break in slope, or on a ridge top 84% of the time.

Overall implementation ratings of the Forest Practice Rules relating to landings are displayed in Table A-3. A total of 23 questions were developed from 20 Forest Practice Rules. Table 15 shows that for Rule requirements with at least 30 observations, four were found to have more than 5% major and minor departures. The Rule with the highest percentage of total departure was 923.1(a), which requires the RPF to map landings greater than one-quarter acre in size, or those requiring substantial excavation. About 10% of the landings were judged to have either minor or major departure from the Forest Practice Rule requiring adequate numbers of drainage facilities. Rules requiring treatment of fill material when it has access to a watercourse and rocking of wet areas had smaller percentages of departures from stated requirements.

Table 15. Landing related Forest Practice Rule requirements with more than 5% departures based on at least 30 observations where implementation could be rated (note that table is ordered by total departures).

Forest Practice Rule	Description	Minor Departure (%)	Major Departure (%)
923.1(a)	Landings>1/4ac or substantial excavation--shown on THP map	11.0	5.9
923.1(f)	Adequate #s of drainage structures	9.0	1.5
923.5(f)(2,4)	Fill extending 20ft with access to watercourse—treated	8.5	0
923.6	Wet spots rocked or treated	6.5	0

Problem points were described for specific components of landings where they were observed by the field team. A total of 36 problem points were recorded, equating to an average of approximately one problem point for every eight landings evaluated. While seven Forest Practice Rules were cited as being poorly implemented causing these problem points, only 923.1(f) which requires adequate drainage structures, was cited frequently (Table 16). All of the problem points encountered at landings were judged to be due to either minor or major departures from specific Forest Practice Rule requirements.

Table 16. Forest Practice Rules that account for approximately 90% of all the Rule requirements rated for implementation at problem points for landings).

Forest Practice Rule	# of Times FPR Cited	Description of Rules Rated for Implementation where Problems Occurred	Exceeds/ Met Rule (%)	Minor (%)	Major (%)
923.1(f)	24	Adequate #s of drainage structures	0	79.2	20.8
923.5(f)(3)	6	Sloped/ditched to prevent erosion	0	83.3	16.7
923.8	3	Abandonment-minimize concentration of runoff	0	100	0
923.5(f)(2)	2	Ditches associated with the landing clear of obstructions	0	100	0

The problem points associated with the landings evaluated are displayed in Table 17. The majority of the problems were associated with either fill slopes or surface drainage features. Presence of significant erosion features (rills or gullies) below the edge of the landing surface associated with drainage structure outlets were the most frequently cited type of problem encountered. Significant amounts of sediment transport were cited as problem points on only four occasions.

Table 17. Distribution of problem points noted at landings.

Type of Problem	Cut Slopes	Fill Slopes	Surface	Below Edge of Landing
Mass Failures	1	3		
Gullies		6		
Rilling	1	3	4	
Rilling/Gullying				14
Sediment Transport		1	3	

The complete summary of the landing effectiveness questions is displayed in Table A-4. Rills or gullies resulting from concentrated flow at drainage structure outlets were present about 28% of the time, and erosion features extending beyond 20 feet below the edge of the landing were found slightly more than 5% of the time.

The location of sediment deposition originating from landing surfaces and fill slopes was also evaluated (Figure 5). For fill slopes, 2% of the time material entered channels, with another 3% reaching the WLPZ. Similarly for surface drainage, 1.5% reached channels, with another 5% reaching the WLPZ.

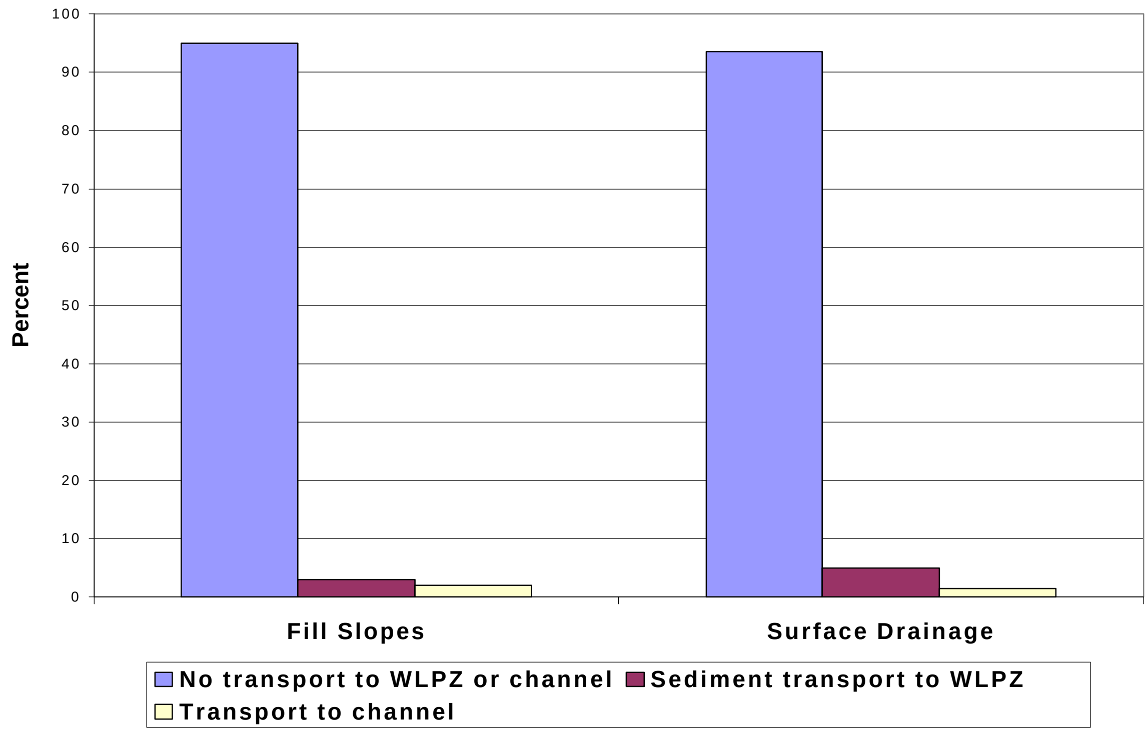

Figure 6. Sediment deposition sites associated with landing fill slopes and surface drainage.

Watercourse Crossings

A total of 263 watercourse crossings were evaluated from 1996 through 1998. Approximately 73% were crossings with culverts, while 16.5% were fords, 2.5% were structural crossings, and 8% were other types of crossings. Seventy percent of the crossings were associated with seasonal roads, 19% with permanent roads, 5% with temporary roads, and 6% with skid trails. Eighty-five percent of the crossings were existing when evaluated, 8% were abandoned, and 7% were removed for the winter period. Fifty percent of the crossings were in Class III watercourses, 45% in Class II drainages, 4% in Class I's, and less than 1% in Class IV watercourses.

Overall implementation ratings of the Forest Practice Rules relating to crossings are displayed in Table A-5. A total of 27 questions were rated for implementation and were developed from 24 Forest Practice Rules. Table 18 shows that for Rule requirements with at least 30 observations, 14 were found to have more than 5% major and minor departures. The Rule with the highest percentage of total departure is 923.2(o), which prevents discharge onto erodible fill material unless energy dissipators are used. Numerous rules requiring proper channel configuration following crossing removal or abandonment also had high departures from stated requirements. The Rules requiring crossings to avoid diversion potential, fills built to minimize erosion, crossings open to unrestricted passage of water, and trash racks in place where appropriate also were cited as having substantial departure percentages.

Problem points were described for specific components of crossings where encountered. A total of 254 problem points were recorded, equating to nearly one problem point for every crossing evaluated. Thirty-seven percent of the watercourse crossings had problem points assigned, indicating that deficient crossings generally had more than one problem point. Poor implementation of 22 Forest Practice Rules were cited as being responsible for these problem points, with 14 Rule requirements being cited the majority of the time (Table 19). All of the problem points were judged to be due to either minor or major departures from requirements of specific Forest Practice Rules. Approximately 64% of the Rule implementation ratings for watercourse crossing problem points were judged to be minor departures, while 36% were rated as major departures from Rule requirements.[12]

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[12] Minor and major departures from Rule requirements for crossings relate to the severity of the problem discovered and less on sediment delivery (since sediment delivery at crossings is assumed to be 100%). For example, a culvert with 10% blockage would equate to a minor departure for 923.4(d), while a culvert with 50% blockage would be rated as a major departure.

Table 18. Watercourse crossing related Forest Practice Rule requirements with more than 5% departures based on at least 30 observations where implementation could be rated (note that some Rules are broken into component requirements, table is ordered by total departures).

Forest Practice Rule	Description	Minor Departure (%)	Major Departure (%)
923.2(o)	No discharge on fill unless energy dissipators are used	13.5	7.1
923.3(d)(1)	Removed-fills excavated to reform channel	16.1	3.2
923.8	Abandonment—minimized concentration of runoff water	12.9	6.5
923.2(d)	Fills across channels built to minimize erosion	10.8	6.7
923.4(1)	Trash racks installed where lots of LWD	12.8	5.1
923.8(d)	Abandonment—pulling/shaping of fills	6.7	10.0
923.4(n)	Crossing/approaches maintained to avoid diversion	14.1	2.4
923.3(d)(2)	Removed-cut bank sloped back to prevent slumping	9.7	6.5
923.3(e)	Crossings/fills built to prevent diversion	10.7	3.4
923.4(c)	Waterbreaks maintained to divert into cover	12.9	0.8
923.4(d)	Crossing open to unrestricted flow of water	9.7	3.4
923.4(d)	Trash racks installed where needed at inlets	6.7	6.7
923.2(h)	Drainage structures of sufficient size, #, and location to carry runoff water	6.5	5.8
923.4	Trash racks in place as specified in THP	6.1	0

The problem points associated with crossings are displayed in Table 20. Fill slope gullies, culvert plugging, and diversion accounted for 15, 14, and 11% of the problem points, respectively. Fill slope failures (7%), fill slope rilling (7%), and fill slope vegetative cover (6%) accounted for smaller percentages of problem points.

The complete summary of the crossing effectiveness questions is displayed in Table A-6. Significant scour at the outlet of crossings was found 35% of the time, with some degree of plugging occurring 22% of the time. Diversion potential was noted for about 17% of the culverted crossings. Almost 40% of the fill slopes at crossings had some amount of slope failure present. Road surface drainage towards the crossing had either slight or significant sediment delivery 36% of the time. For abandoned or removed crossings, approximately 80% had channels established close to natural grade and orientation, with about 20% having minor or major differences. Sediment delivery to watercourses can generally be assumed to be 100% at crossings since these structures are built directly in channels.

Table 19. Forest Practice Rules that account for approximately 90% of all the Rule requirements rated for implementation at problem points for watercourse crossings.

Forest Practice Rule	# of Times FPR Cited	Description of Rules Rated for Implementation where Problems Occurred	Exceeds/ Met Rule (%)	% Minor Departure	% Major Departure
923.2(o)	36	No discharge on fill without energy dissipators	0	58.3	41.7
923.4(n)	32	Crossing/approaches maintained to avoid diversion potential	0	84.4	15.6
923.2(h)	31	Structures of sufficient size, #, locations to minimize erosion	0	51.6	48.4
923.3(e)	27	Crossing/fill built to prevent diversion	0	66.7	33.3
923.4(d)	27	Crossing open to unrestricted passage of water	0	66.7	33.3
923.2(d)	24	Fills across channels built to minimize erosion	0	50.0	50.0
923.4(c)	12	Waterbreaks maintained to divert water into cover	0	91.7	8.3
923.2(h)	10	Size, #, location of structures sufficient to carry runoff water	0	30	70
923.8	7	Abandonment-minimizes concentration of runoff, erosion	0	57.1	42.9
923.8(b)	7	Abandonment-adequate stabilization of exposed soil on cuts, fills, sidecast	0	57.1	42.9
923.4(1)	6	Trash rack installed where LWD	0	83.3	16.7
923.8(d)	6	Abandonment-pulling/shaping fills	0	50	50
923.3(d)(2)	6	Removed-excavated material sloped back and stabilized to prevent erosion	0	66.7	33.3
923.2(h)	6	Size, #, location of structures sufficient to maintain drainage pattern	0	83.3	16.7

Table 20. Distribution of problem points noted at watercourse crossings.

Drainage Type	Problem Type	Count
Culvert	Plugging	36
	Diversion	29
	Scour at outlet	13
	Gradient	12
	Scour at inlet	4
	Piping	3
	Crushed	2
	Corrosion	1
Fill Slopes	Gullies	38
	Slope failures	18
	Rilling	17
	Vegetative cover	16
	Cracks	4
Road Surface Draining to Crossings	Rutting	7
	Inside Ditch	5
	Rilling	5
	Ponding	4
	Gullies	2
Non-Culvert Crossing	Armoring	7
	Scour at outlet	3
Removed/Abandoned Crossing	Road Approach-grading	10
	Grading/Shaping	7
	Channel bank gullies	4
	Configuration	5
	Channel bank slope failure	1
	Bank stabilization	1

Watercourse and Lake Protection Zones (WLPZs)

The Hillslope Monitoring Program sampled 274 watercourse and lake protection zone (WLPZ) transects, with a total of 244,940 feet (46.39 mi) of transects evaluated.[13] Approximately 76% of the transects were along Class II watercourses, 23% next to Class I watercourses, and 1% beside Class III watercourses with WLPZs. For about 43% of the transects, the slope distance from the channel bank to the nearest road was greater than 150 feet; 17% had a distance of 50-100 feet, 15% had a distance of 100-150 feet, 14% had a distance of 0-20 feet, and 11% had a distance of 20-50 feet.

Following the completion of WLPZ transect(s), the field team rated the overall implementation of specific Forest Practice Rules related to WLPZs (Table A-7). A total of 55 questions were developed from 34 Forest Practice Rules. Table 21 shows that for Rule requirements with at least 30 observations, six were found to have more than 5% major and minor departures. Three of these Rules deal with the requirement for the RPF to evaluate riparian areas for sensitive conditions—including unstable and erodible watercourse banks and use of existing roads within the standard WLPZ. These factors are to be identified in the THP and considered when proposing WLPZ widths and protection measures. Two Rules cited require that WLPZ widths be at least equal to that specified in Table 1 in the Forest Practice Rules. The remaining Rule requires accidental depositions of soil to be removed from watercourses.

Very few erosion features caused by current Timber Harvesting Plans were noted when completing the WLPZ transects (Table 22). Most of the erosion features noted were judged to either predate the current THP, were created after the THP but were not affected by the THP, or it was impossible to determine the feature date. Only one of the mass failures was associated with problems with Rule implementation. The remaining features were natural streambank or inner gorge failures not related to logging operations. Total erosion volumes for mass failures and gullying were 2,050 and 65 yd^3, respectively.

[13] Class III watercourses were not evaluated from 1996 through 1998, but a pilot project for evaluating protection of Class III watercourses is expected to be implemented during the summer of 1999.

Table 21. WLPZ related Forest Practice Rule requirements with more than 5% departures based on at least 30 observations where implementation could be rated (note that some Rules are broken into component requirements, table is ordered by total departures).

Forest Practice Rule	Description	Minor Departure (%)	Major Departure (%)
916.4(a)	Sensitive conditions—erodible banks—identified in THP	9.0	1.8
916.2(a)(4)	Sensitive conditions—existing roads in WLPZ—appropriate mitigation measure applied	7.0	2.8
916.4(a)	Sensitive conditions—existing roads in WLPZ—identified in THP	5.7	2.9
916.4(b)(3)	Width of WLPZ conforms to Table 1 in FPRs	6.4	0.8
916.4(b)	WLPZ widths as wide as specified in Table 1	5.6	0.8
916.3(b)	Accidental depositions of soil removed from watercourses	5.9	0

Table 22. Erosion features associated with the current THP and recorded during WLPZ transect evaluations.

Erosion Feature	Count
Cutbank or sidecast sloughing	1
Mass Failure	13
Gullying	4
Rilling	5

Mean WLPZ widths and side slope gradients were estimated for the transects evaluated. Mean widths for side slope categories are displayed in Table 23. It was often difficult for the field team to determine the upper extent of the WLPZ—particularly where selective silvicultural systems were used above the WLPZ. Flagging used to denote the WLPZ commonly is very difficult to locate following several overwintering periods. Therefore, the WLPZ widths must be regarded as rough estimates. It is also unknown at this time how many of these WLPZs utilized the allowable reduction granted for using cable yarding systems above the WLPZ (50 ft reduction for Class I and 25 ft reduction for Class II watercoures). Thirty percent of the WLPZ transects had only cable or helicopter yarding upslope of the transect.

Ground cover was evaluated at 100 foot intervals along the WLPZ transects. Mean ground cover was estimated to be 87 percent. It should be noted that ground cover varied greatly for different Forest Practice Districts. In the Coast District, higher moisture levels create more leaf fall and forb cover—resulting in very high ground cover, while in the drier inland districts, bare soil is common in WLPZs even without logging disturbances. Canopy cover was estimated with the spherical densiometer (1996 without modification, 1997-98 with the Strickler (1959) modification to reduce bias). Mean canopy was found to be above 70% in all cases (Table 24).[14] Canopy estimates are for total canopy in all cases (not overstory or understory, as is specified for Class I watercourses).

Table 23. Mean WLPZ width estimates.

Watercourse Class	Side Slope Gradient Category (%)	Mean WLPZ Width (ft)	Standard Forest Practice Rule (ft)
I	<30	80	75
	30-50	100	100
	>=50	115	100-150[15]
II	<30	55	50
	30-50	75	75
	>=50	90	75-100

Table 24. Mean WLPZ canopy estimates.

Watercourse Class	Year/Location	Canopy (%)
I	1996 (North Coast)	79
I	1997-1998 (statewide)	74
II	1996 (North Coast)	77
II	1997-1998 (statewide)	75

[14] Robards et al. (1999) have reported that the spherical densiometer produces a biased estimate of canopy and recommend the use of the sighting tube to reduce bias. In a field test conducted on Jackson Demonstration State Forest, the range of densiometer estimates was reported to be from 20% low to 10% high compared to actual canopy closure. In 1999, the Hillslope Monitoring Program will use the sighting tube for estimating canopy cover.

[15] 50 foot and 25 foot reductions in WLPZ width are allowed with cable yarding for Class I and II watercourses, respectively.

Large Erosion Events

Large erosion events were identified when traveling within the THP; as part of the evaluations for randomly located road segments, skid trail segments, landings, crossings, and WLPZs; or from information provided by landowners. The type, size, location, and cause of the large erosion event were described. This work was completed only for the statewide survey completed in 1997-1998 (not for the 1996 work in Mendocino and Humboldt Counties). For the 100 THPs included for this evaluation, a total of 35 large events were documented. Of these, 27 were related to current timber management activities (Table 25). Nearly all the shallow debris slides described were found in the Coast Forest Practice District, as were half of the deep seated rotational failures. Six of the ten catastrophic crossing failures were from the Southern Forest Practice District, largely due to the very large rain-on-snow event which occurred in January 1997 (100-yr+ in many Sierran watersheds). Large erosion events were located on 24 of the 100 THPs, with seven THPs having multiple large erosion events.

Mean erosion volumes for the various types of features related to current management activities are as follows: deep seated rotational (3,600 yd^3), shallow debris slide (3,700 yd^3), catastrophic crossing failure (200 yd^3), and streambank failure (600 yd^3). Most of the large erosion events were related to roads (24), with smaller numbers associated with landings (2) and skid trails (3). Eight of the features were judged to be unrelated to current management activities.[16] General cause code and associated feature type are displayed in Figure 6. Specific causes associated with the large erosion events are displayed in Table 26. The most frequent causes associated with large erosion events were: cutbanks with slope support removed; culverts with the inlet plugged; fill slopes with overloaded, deep sidecast; fill slopes with poorly compacted material; and surface water concentration.

[16] Note that multiple causes were assigned in some instances, so the total is greater than the total number of large erosion events.

Table 25. Frequency distribution of large erosion events related to current management activities that were encountered on THPs evaluated from 1997-1998.

Type	Coast	Northern	Southern	Total
Deep seated rotational	3	2	1	6
Shallow debris slide	9	1	0	10
Catastrophic crossing failure	1	3	6	10
Streambank failure	0	0	1	1
Total	**13**	**6**	**8**	**27**

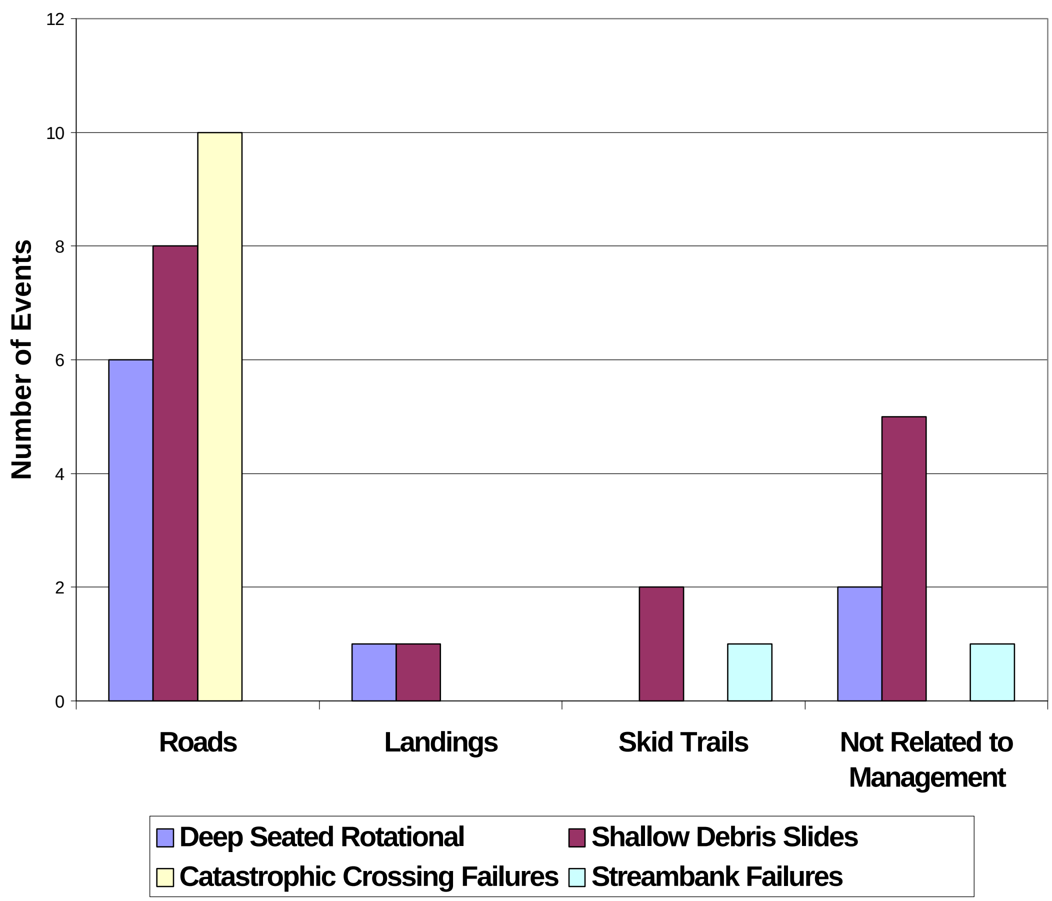

Figure 7. Causes of large erosion events and type of feature.

Table 26. Specific management related causes associated with large erosion events.

Type	Cause of Feature	Count
Roads		
	Waterbars-discharge onto erodible material	1
	Waterbars-improperly constructed or located	2
	Fill slopes-too steep	2
	Fill slopes-overloaded, deep sidecast	4
	Fill slopes-poorly compacted	4
	Fill slopes-excessive organic material	1
	Surface water concentration	4
	Culverts too small	2
	Culverts-discharge onto erodible material	1
	Culverts-inlet plugged	4
	Inside ditch-ditch blocked and/or diverted	1
	Inside ditch-other drainage onto road no handled	2
	Cutbanks- too steep	1
	Cutbanks-slope support removed	7
	Subsurface flow alteration	1
Skid Trails		
	Waterbars-not properly draining area	1
	Cutbanks-too steep	1
	Cutbanks-slope support removed	2
	Surface water concentration-rilling and gullying	1
	Surface water concentration-discharge on erodible material	1
Landings		
	Cutbanks-too steep	1
	Cutbanks-slope support removed	1
	Fill slopes-excessive organic material	1

DISCUSSION AND CONCLUSIONS

The data that has been collected to date as part of the Hillslope Monitoring Program point toward several preliminary conclusions. This is an on-going program, and additional information and more detailed queries will be available for future reports. Therefore, it is still too early to arrive at final conclusions. Further, this work has evaluated the implementation and effectiveness of selected **standard** Forest Practice Rules that can be evaluated in the field (not alternative or in-lieu practices). It also did not evaluate the THP "review process" or the degree to which this process contributes to observed water quality problems (Lee 1997). Finally, it is important to note that only THPs have been evaluated, not Exemptions, Emergency Notices, Conversions, or Non-industrial Timber Management Plans (NTMPs).

The following preliminary conclusions are based on data collected to date for the implementation and effectiveness of standard Forest Practice Rules related to water quality that could be evaluated in the field at selected sites (i.e., roads, landings, skid trails, crossings and WLPZs) on 150 THPs:

1. **Erosion problem points noted for roads, skid trails, landings, crossings, and WLPZs were almost always associated with improperly implemented Forest Practice Rules.**

The data collected to date suggests that the vast majority of erosion problem points were caused by minor or major departures from specific Forest Practice Rule requirements. Nearly all the problem points were judged to result from non-compliance. For example on the road transects, only about three percent of the implementation ratings assigned at erosion features were for situations where the Rule requirements were judged to have been met or exceeded.

The Forest Practice Rules and individual THP requirements (i.e., site-specific mitigation measures developed through recommendations of interagency Review Teams) were generally found to be sufficient to prevent hillslope erosion features when properly implemented on the ground by Licensed Timber Operators (LTOs).[17] To improve implementation, new training programs for LTOs and their employees should be encouraged, and these programs should include a field component.

[17] Rice and Datzman (1981) previously reported that operator performance may equal site characteristics as a source of variation in logging related erosion.

2. Roads and their associated crossings were found to have the greatest potential for delivery of sediment to watercourses. Implementation of Forest Practice Rules that specify drainage structure design, construction and maintenance need improvement.

More than 80% of the road transects evaluated from 1996 through 1998 were seasonal roads, and less than 30% of the sampled road mileage was surfaced with rock. Overall, 36 Rule requirements for roads and crossings were found to have more than 5% minor and major departures, considerably more than that found for landings, skid trails and WLPZs. The Forest Practice Rules with the highest departures from stated road requirements were related to waterbreak spacing, maintenance, and construction standards; adequate number, size, and location of drainage structures; prevention of discharge onto erodible fill; and sidecast limitations on steep slopes. Erosion problem points were noted, on average, approximately every 400 feet. Rilling was common, but had low sediment delivery to channels; mass failures were noted much less frequently but had high sediment delivery. Rilling and gullying were primarily caused by drainage feature problems, while mass failures were most commonly associated with unstable fill material.

In most types of terranes, earlier studies have reported that roads produce 75-95% of the erosion related to timber operations (Rice 1989). Based on the data collected to date as part of this program, these estimates still seem reasonable in the late 1990's.[18] The data suggests that there is considerable room for improvement in road design and construction—particularly regarding fill slopes, cutslopes, and crossings (see No. 4 below). As documented by Lewis and Rice (1989) as part of the Critical Sites Erosion Study, site factors overwhelm management impacts in most terranes. Therefore, *where* roads are built will remain critical for reducing the likelihood of producing significant sediment input to channels.

3. Mass failures related to current timber operations are most closely associated with roads and produce the highest sediment delivery to watercourse channels when compared to other erosional processes.

Data from 100 THPs shows that about one-quarter of the plans had large erosion features. More than 80% of the large erosion events that were documented as part of the statewide survey were associated with roads and crossings. Estimates from the randomly located road transects revealed that about 50% of the mass failures delivered material to stream channels—much higher than the

[18] Exceptions include landscapes that are highly unstable and have significant components of erosion resulting from inner gorge landsliding, such as have been found in portions of southern Humboldt County (PWA 1998).

average sediment delivery associated with sloughing, rilling, and gullying. The majority of the mass failures were associated with fill slopes, with cutbank and culvert problems also commonly noted. The data from both the large erosion event record and the randomly located road transects suggests that RPFs must locate and design, and LTOs must construct, drain, and maintain roads in a manner that will reduce the frequency of mass failure events.

4. Numerous problems were noted at watercourse crossings. Implementation of Forest Practice Rules that specify design, construction, and maintenance of crossings require considerable improvement.

Conclusions about watercourse crossings are based on a sample with 95% of the crossings in Class II or III watercourses. Very few Class I crossings were reviewed, because the random selection of crossings was tied to road transects and roads that were commonly located high on hillslopes. Only 15% of the crossings evaluated had been removed or abandoned, so the sample sizes for these types of crossings is still relatively small. The data collected to date shows that problem points at watercourse crossings are a major source of sediment delivered to watercourses. Because crossings are adjacent to and within channels, eroded material has direct access to the watercourses. Approximately 40% of the crossings had one or more problems, while more than 60% had none, indicating that they were functioning properly. Common problems included fill slope gullies, plugging, scour at the outlet, and high diversion potential. Although not readily derived from the database, the field crew members observed that where a well designed and constructed crossing was encountered in a THP being reviewed, the other crossings in the plan were usually also well constructed. These data indicate that more attention is needed with the design, construction, and review of crossings. Recent research has provided RPFs and Licensed Timber Operators new information on how to build better crossings (Flanagan et al. 1998).

5. Watercourse and lake protection zones (WLPZs) have been found to generally meet Forest Practice Rule requirements for width, canopy, and ground cover. Additionally, very few erosion features associated with current THPs were recorded in WLPZs.

Approximately three-quarters of the WLPZs evaluated to date have been on Class II watercourses, which are much more common than the generally larger Class I waters. The data collected in WLPZs indicates that minimum canopy requirements following harvesting on Class I and II watercourses are being exceeded, since an average of greater than 70% canopy cover following harvesting has been measured using the spherical densiometer. Similarly, mean ground cover requirements in WLPZs following logging was estimated to exceed 85%. Required WLPZ widths generally met Rule requirements, with major departures from Rule requirements noted only about 1% of the time. Erosion events originating from current THPs and encountered on mid-zone or streambank WLPZ transects were found to be rare. The implementation data suggests that RPFs should do a better job of taking existing roads and erodible, unstable stream banks into account when designing WLPZs and specifying protection measures.

6. **Landings did not have substantial numbers of erosion events associated with current operations and erosion events on landings generally did not transport sediment to watercourses.**

More than half of the randomly selected landings were greater than 300 feet from the nearest watercourse (I, II, III, or IV), almost 90% were built on slopes less than 45%, and more than 80% were built on a ridge or above the break in slope. These factors indicate why landings generally did not create significant water quality problems and why very few erosion events transported sediment from landings, with the exception of landings located very near watercourses (generally old landings built for previous entries). Drainage structures associated with landings were cited as needing improvement about 10% of the time, but most of the Rule requirement implementation ratings were for minor departures, indicating that direct adverse impacts to water quality were infrequent.

7. **Skid trail segments had a lower frequency of erosion features related to current operations when compared to road segments. Overall, skid trails are having much less impact to water quality than roads.**

The frequency of erosion problems noted on skid trail transects was fairly low when compared to problems documented on roads. For example, problem points assigned to waterbreaks that did not conform to the Rule requirements on skid trails occurred at about half the rate as on road transects (i.e., 4% vs. 9%). The overall average was one erosion problem point assigned for every 1,175 feet of skid trail evaluated, verses one problem every 380 feet for roads. Rills were noted fairly frequently on skid trails but had very low delivery to watercourse channels. Gullies were noted with about one-third the frequency of rills, but had a higher percentage of sediment delivery to watercourse channels. Spacing of waterbreaks was the most commonly cited drainage feature problem associated with skid trail rilling and gullying.

8. **Recent timber operations cannot be linked to current instream channel conditions based on results from the Hillslope Monitoring Program.**

This program has evaluated Forest Practice Rule effectiveness on hillslopes—not in the stream channels. This type of monitoring can provide a rapid feedback loop to managers for improving hillslope practices. It does not, however, address current instream channel conditions which are often the result of land use impacts that took place decades ago. Instream measurements can be difficult to relate to individual forest practices (Murphy 1995). In addition, results presented in this interim report do not allow us to draw conclusions about whether the existing Rules are providing properly functioning habitat for aquatic species because evaluating the biological significance of the current Rules is not part of this project. For example, hillslope monitoring in WLPZs does not allow us to draw conclusions regarding whether canopy levels resulted in acceptable water temperatures for anadromous fish, or whether the observed timber operations retained an adequate number of mature trees for large woody debris recruitment that is needed to create complex habitats for anadromous fish species. Also, the adequacy of the Rules in addressing cumulative watershed effects are not covered by this program.[19]

GENERAL OBSERVATIONS

The findings of this interim report mirror those of the “208 Team” (SWRCB 1987), where it was reported that: (1) the standard Rules generally appeared to provide adequate water quality protection when they were properly implemented, and (2) poor Rule implementation was the most common cause of observed water quality impacts. More than 95% of the Forest Practice Rules associated with erosion problem points encountered from 1996 through 1998 were rated as having either minor or major departures from Rule requirements. This indicates that the Rules are generally effective in preventing erosion events when properly implemented. In a nation-wide survey on monitoring, Brown and Binkley (1994) reported that forest practices can protect water quality if prescriptions are carefully developed and implemented.

The Forest Practice Rules listed in Table 27 have been identified as having the highest percentages of total departures from Rule requirements and should be made known to RPFs, LTOs and their employees, and to CDF Forest Practice Inspectors. They need to be made aware of which Rules are not being

[19] The adequacy of the Forest Practice Rules addressing cumulative watershed effects is currently being reviewed by several scientific and agency task forces, with final reports expected during the summer of 1999.

implemented well in the field, and these groups should be targeted for intense training efforts.

Much remains to be learned about Forest Practice Rule implementation and effectiveness. Many of the Forest Practice Rules have not been adequately tested to date because the situations in which they apply are very limited. The continued long-term collection of hillslope data will enable the performance of these Rules to be adequately reviewed. Similarly, many situations have yet to be fully studied as part of the Hillslope Monitoring Program. For example, protection of Class III watercourses has yet to be addressed. Class III protection was noted as one of three areas of Rule requirements where concerns were expressed over both implementation and effectiveness by resource professionals in a survey of watercourse and lake protection zone protection measures (CDF 1995).[20] Similarly, impacts to hillslopes that have been cable yarded have not been included in the program (other than documenting large erosion events where encountered). The evaluation of non-standard practices (in-lieu and alternative practices) will also require considerably more work before conclusions can be made whether these practices provide the same level of protection as the standard Rules.[21]

The Hillslope Monitoring Program can be improved in several areas. Only a small amount of quality assurance/quality (QA/QC) control work has been completed to date to test the repeatability of the data reported.[22] CDF conducted very limited QA/QC work for canopy measurements in 1996 and found that the canopy measurements reported by the contractors was approximately 7% higher than that estimated internally. Transects established on 10 THPs from the 1997 THPs have been remeasured but that data has yet to be compared to the original data. Recent CDF staff additions will allow improved QA/QC work in the future. In addition, CDF has yet to implement a program to resample a certain percentage of THPs to monitor impacts from strong stressing storms. This work would be particularly important on those THPs which had not been tested by large storm events during the overwintering periods prior to the first THP

[20] The other two areas were winter operations and restorable uses of water.

[21] The SWRCB (1987) report stated that the use of non-standard practices frequently resulted in less protection than would have been provided by standard practices.

[22] Even though little work has been completed to test repeatability, the data presented in this report was collected with a high degree of consistency, since R.J. Poff and Associates evaluated 125 out of 150 THPs.

evaluation.[23] There are plans to begin this type of expanded hillslope monitoring program in the near future.

Table 27. Forest Practice Rule requirements with at least 10% total departures based on at least 30 observations where implementation could be rated (note this table was developed from Tables 4, 11, 15, 18, and 21).

Location	Rule No.	Description
Roads/ skid trails	914.6(c)	Waterbreak spacing equals standards
Roads/ landings	923.1(f)	Adequate numbers of drainage facilities
Roads	923.2(b)	Sidecast minimized for slopes > 65% for distances > 100 ft
Roads	923.1(d)	For slopes >65% or 50% within 100 ft of WLPZ, soil treated to minimize erosion
Roads/ crossings	923.2(h)	Drainage structures of sufficient size, number and location to minimize erosion, carry runoff water
Roads/ crossings	923.2(o)	No discharge onto erodible fill unless energy dissipators are used
Roads	914.6(g)	Waterbreaks have an embankment of at least 6 inches
Roads/ crossings	923.4(c)	Waterbreaks maintained to divert into cover
Roads	923.2(h)	Drainage structures of sufficient size, number and location to minimize erosion
Roads	914.6(f)	Waterbreaks installed to discharge into cover
Roads/ landings	923.1(a)	If landing on road >1/4 ac or required substantial excavation, --shown on THP map
Roads	914.6(g)	Waterbreaks constructed with a depth of at least 6 inches cut into firm roadbed
Roads	923.2(p)	Waterbreaks installed according to standards in 914.6
Skid trails	914.6(f)	Where waterbreaks cannot disperse runoff, other erosion controls installed as needed
WLPZ	916.4(a)	Sensitive conditions—erodible banks identified in THP
Crossings	923.3(d)(1)	Removed fills excavated to reform channel
Crossings	923.8	Abandonment—minimizes concentration of runoff water
Crossings	923.2(d)	Fills across channels built to minimize erosion
Crossings	923.4(1)	Trash racks installed where abundant LWD
Crossings	923.8(d)	Abandonment-pulling/shaping of fills
Crossings	923.4(n)	Crossings/approaches maintained to avoid diversion
Crossings	923.3(d)(2)	Removed crossings-cut bank sloped back to prevent slumping
Crossings	923.4(d)	Crossing open to unrestricted passage of water
Crossings	923.4(d)	Trash racks installed where needed at inlets
Crossings	923.3(e)	Crossings/fills built to prevent diversion

[23] Lewis and Baldwin (1997) suggest that stressing storm events need to be defined and effectiveness should only be evaluated after stressing events have occurred. Some measure of the magnitude of the stressing events should be included in the analysis.

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GLOSSARY

Abandonment – Leaving a logging road reasonably impassable to standard production four wheel-drive highway vehicles, and leaving a logging road and landings, in a condition which provides for long-term functioning of erosion controls with little or no continuing maintenance (CFPR 895.1).

Beneficial uses of water - According to the Porter-Cologne Water Quality Control Act, the beneficial uses of water include, but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish and wildlife, and other aquatic resources or preserves. In Water Quality Control Plans, the beneficial uses designated for a given body of water typically include the following: domestic, municipal, agricultural, and industrial supply; industrial process; water contact recreation and non-water contact recreation; hydropower generation; navigation; groundwater recharge; fish spawning, rearing, and migration; aquatic habitat for warm-water species; aquatic habitat for coldwater species; and aquatic habitat for rare, threatened, and/or endangered species (Lee 1997).

Best management practice (BMP) - A practice or set of practices that is the most effective means of preventing or reducing the generation of nonpoint source pollution from a particular type of land use (e.g., silviculture) that is feasible, given environmental, economic, institutional, and technical constraints. Application of BMPs is intended to achieve compliance with applicable water quality requirements (Lee 1997).

Canopy - the foliage, branches, and trunks of vegetation that blocks a view of the sky along a vertical projection, and estimated from 1996 through1998 for this project with a spherical densiometer. The Forest Practice Rules define canopy as the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody species (CFPR 895.1).

Cutbank/sidecast sloughing - Shallow surficial sliding associated with either the cutbank of fill material of a forest road, with smaller dimensions than would be associated with mass failures.

Feature - Any constructed feature along a landing, road, skid trail, or watercourse crossing (e.g., cut bank, fill slope, inside ditch, cross drain, water bar).

Gully - Erosion channels deeper than 6 inches (no limitation on length or width). Gully dimensions were estimated.

Large erosion event - For hillslope mass failures, these events are 100 cubic yards for a void left on a hillslope; for catastrophic crossing failures, these events are defined as at least 10 cubic yards.

Mass failure – Downslope movement of debris that occurs when the internal strength of a soil is exceeded by gravitational and other stresses. Mass erosion processes include slow moving, deep-seated earthflows and rotational failures, as well as rapid, shallow movements on hillslopes (debris slides) and downstream channels (debris torrents).

Minor/major departure – Major departures were assigned when sediment was delivered to watercourses, or when there was a substantial departure from Rule requirements (e.g., no or few waterbars installed for entire transect). Minor departures were assigned for slight Rule departures where there was no evidence that sediment was delivered to watercourses (e.g., WLPZ width slightly less than that specified by the Rule).

Non-standard practice - A practice other than a standard practice, but allowable by the Rules as an alternative practice, in-lieu practice, waiver, exclusion, or exemption (Lee 1997).

Parameter - The variable being studied by sampling, observation, or measurement (Lee 1997).

Permanent road – A road which is planed and constructed to be part of a permanent all-season transportation facility. These roads have a surface which is suitable for the hauling of forest products throughout the entire winter period and have drainage structures, if any at watercourse crossings which will accommodate the fifty-year flow. Normally they are maintained during the winter period (CFPR 895.1).

Problem point - In Hillslope Monitoring Program, the occurrence of: (a) rilling, gullying, mass failures, or cutbank/sidecast sloughing found along landings, roads, skid trails, watercourse crossings, or WLPZs and (b) canopy reduction, streambank erosion, or ground cover reduction in a WLPZ. Problem points also include Forest Practice Rule violations (e.g., waterbreak improperly constructed) (Lee 1997).

Process - The process by which the Rules/BMPs are administered and implemented, including: (a) the process elements for THP preparation, information content, review and approval by RPFs, Review Team agencies, and CDF decision-makers, and (b) the process elements for timber operation conduct, inspection, and completion by LTOs and CDF inspectors (Lee 1997).

Quality assurance - The steps taken to ensure that a product (i.e., monitoring data) meets specified objectives or standards. This can include: specification of the objectives for the program and for data (i.e., precision, accuracy, completeness, representativeness, comparability, and repeatability), minimum personnel qualifications (i.e., education, training, experience), training programs, reference materials (i.e., protocols, instructions, guidelines, forms) for use in the field, laboratory, office, and data management system (Lee 1997).

Quality control - The steps taken to ensure that products which do not meet specified objectives or standards (i.e., data errors and omissions, analytical errors) are detected and either eliminated or corrected (Lee 1997).

Repeatability - The degree of agreement between measurements or values of a monitoring parameter made under the same conditions by different observers (Lee 1997).

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (CFPR 895.1).

Standard practice - A practice prescribed or proscribed by the Rules (Lee 1997).

Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (CFPR 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (CFPR 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted therefrom. Waterbreaks are synonymous with waterbars (CFPR 895.1).

Appendix[24]

[24] For Tables A-1, A-2, A-3, A-5, and A-7, the columns are defined as follows: (1) Forest Practice Rule number, (2) brief description of Forest Practice Rule, (3) total number of times the Rule was rated for implementation following evaluation of the entire transect/feature, (4) total number of times implementation rating was either exceeded Rule requirements, met Rule requirements, minor departure from Rule requirements, or major departure from Rule requirements, (5) number of implementation ratings for both exceeded Rule requirements and met Rule requirements divided by column no. 4 and multiplied by 100, (6) number of implementation ratings for minor departure of Rule requirements divided by column no. 4 and multiplied by 100, and (7) number of implementation ratings for major departure of Rule requirements divided by column no. 4 and multiplied by 100.

Table A-1. Roads—implementation ratings for transects as a whole.

Rule No.	Description	Number of Observations	Number of Observations (1-4)	% Meets or Exceeds FPR	% Minor Departure	% Major Departure
923(d)	Road located to avoid bottoms of steep canyons	287	255	98.8	1.2	0
923(d)	Road located to avoid marshes/wet areas	289	209	98.1	1.9	0
923(d)	Road located to avoid unstable areas	289	180	96.1	3.9	0
923(d)	Road located to avoid watercourses	288	268	98.5	1.1	0.4
923.4(i)	Soil stabilization on cuts, fills, sidecast	287	185	95.7	3.8	0.5
923.6	Wet spots rocked or otherwise treated	288	134	93.3	6.7	0.0
923.1(a)	if landing on road >1/4ac, shown on THP map	288	124	87.9	7.3	4.8
1038(b)(5)	Permitted activities-new road construction/reconstr.	288	2	100.0	0.0	0.0
923.4(j)	Drainage ditches maintained to allow flow of water	288	192	92.7	7.3	0.0
914.6(f)	Waterbreaks built to discharge into cover	289	228	87.7	12.3	0.0
914.6(f)	Waterbreaks built to spread water to min. erosion	288	226	97.8	2.2	0.0
914.6(g)	Waterbreaks constructed diagonally	288	220	98.2	1.8	0.0
914.6(g)	Waterbreaks cut to depths of at least 6 inches	288	218	88.1	11.0	0.9
914.6(g)	Waterbreaks have embankment of at least 6 inches	287	215	86.5	12.1	1.4
923(c)	Road planned to fit topography, minimize disturbance	288	287	98.6	1.4	0.0
923(e)	Road located to minimize number of crossings	288	283	99.3	0.7	0.0
923(f)	Road located on benches/flatter slopes, stable soils	288	286	96.2	3.8	0.0
923(g)	Excavation or placement of fills on unstable soils	288	195	97.9	2.1	0.0
923.1(a)	Road shown on THP map correctly	288	286	94.1	5.6	0.3
923.1(a)	if road reconstructed--failures shown on THP map	289	81	96.3	3.7	0.0
923.1(e)	if new, grade> 15% or 20% less than 500 ft	288	77	100.0	0.0	0.0
923.1(f)	Adequate #s of drainage structures to min. erosion	292	288	80.2	16.7	3.1
923.1(g)	Road width appropriated for yarding system used	288	282	99.6	0.4	0.0
923.2(d)C	Fills constructed with insloping approaches, etc	288	82	92.7	6.1	1.2
923.2(d)N	Breaks in grade above/below throughfill	288	100	93.0	7.0	0.0
923.2(g)	Excess material stabilized so as avoid impact	288	263	98.5	0.8	0.8
923.2(h)	Size, #, location of structures okay to carry runoff water	288	281	82.9	13.9	3.2

923.2(h)	Size, #, location of structures sufficient to min. erosion	290	285	83.2	14.4	2.5
923.2(l)	Trees with >25% roots exposed by construction cut	288	269	98.9	0.7	0.4
923.2(m)	Sidecast extending>20 ft treated to avoid erosion	288	76	94.7	2.6	2.6
923.2(o)	Discharge onto erodible fill prevented	289	259	87.6	10.4	1.9
923.2(v)	Construction in WLPZ limited to crossings	288	106	100.0	0.0	0.0
923.4(c)	Waterbreaks maintained to minimize erosion	291	221	80.5	16.7	2.7
923.4(c)	Erosion controls maintained during maintenance period	288	102	94.1	5.9	0.0
923.4(f)	drainage structures removed if not sized for 50-yr flow	288	111	98.2	1.8	0.0
923.4(m)	inlet/outlet structures/add. Structures been maintained	289	202	95.5	4.5	0.0
923.8(a)	abandoned roads-blockage of road completed	288	4	50.0	50.0	0.0
923.8(b)	abandoned roads-stabilization of exposed soil	288	4	100.0	0.0	0.0
923.8(d)	abandoned roads-pulling or shaping of fills/sidecast	288	3	66.7	33.3	0.0
923.8(e)	removed crossing-fills excavated to form appropriate channel	288	4	75.0	25.0	0.0
923.8(e)	removed crossing-excavated material sloped back	288	4	100.0	0.0	0.0
923.8(e)	if removal of crossing not feasible, diversion pot. Handled	287	2	100.0	0.0	0.0
1038(b)(2)	permitted activities-new tractor roads on slopes>40%	288	1	100.0	0.0	0.0
914.6(c)	waterbreak spacing according to standards in 914.6(c)	288	224	77.2	20.1	2.7
914.6(f)	waterbreaks built to provide unrestricted discharge	288	226	98.7	0.9	0.4
914.6(f)	where waterbreaks don't work--other erosion controls	287	115	92.2	7.0	0.9
923.1(d)	slopes >65%, 50% within 100 ft of WLPZ-treat soil	288	49	89.8	8.2	2.0
923.1(g)(3)	insloped roads-adequate number of ditch drains	288	141	95.7	4.3	0.0
923.2(b)	sidecast minimized for slopes >65% distance >100 ft	289	30	83.3	16.7	0.0
923.2(h)	size, #, location of structures-natural drainage pattern	289	272	98.5	1.5	0.0
923.2(I)	trash racks, etc installed where appropriate	289	71	94.4	5.6	0.0
923.2(k)	road without overhanging banks	288	270	99.3	0.7	0.0
923.2(u)	slash placed to avoid discharge to Class I/II	288	223	100.0	0.0	0.0
923.4(e)	roadside berms removed or breached	288	248	98.0	2.0	0.0
923.4(g)	temporary roads blocked before winter period	288	17	64.7	29.4	5.9
923.8(c)	abandonment-shaping to allow dispersal of water	288	4	100.0	0.0	0.0

923.8	abandonment-allows permanent drainage	288	4	75.0	25.0	0.0
923.8	abandonment-minimizes concentration of runoff	287	4	50.0	50.0	0.0
923.2(p)	waterbars installed according to 914.6	287	191	89.5	9.4	1.0

Table A-2. Skid Trails--implementation ratings for transects as a whole.

Rule No.	Description	Number of Observations	Number of Observations (1-4)	% Meets or Exceeds FPR	% Minor Departure	% Major Departure
1038(b)(9)	permitted acts--cutting in WLPZ	240	2	100.0	0.0	0.0
1038(b)(4)	permitted acts--ops on slides, etc.	240	2	100.0	0.0	0.0
1038(b)(6)	permitted acts--ops in WLPZs	240	2	50.0	0.0	50.0
1038, 1038.1	permitted acts--ops comply with FPRs	240	2	100.0	0.0	0.0
914.1(a)	trees felled away from watercourses	243	188	99.5	0.5	0.0
914.2(f)(1)	tractor ops avoided slopes >65%	240	133	100.0	0.0	0.0
914.2(f)(2)	ops avoided slopes>50% above I/II	240	97	99.0	1.0	0.0
914.2(f)(3)	ops avoided slopes>50% high, extreme	241	55	100.0	0.0	0.0
914.3 Coast	ops avoided cable yarding areas	240	34	97.1	2.9	0.0
914.6(f)	waterbreaks allow discharge into cover	240	229	97.8	1.7	0.4
914.6(f)	waterbreaks spread water to min erosion	240	229	96.9	2.2	0.9
914.6(f)	if waterbreaks don't work, other structures	240	76	76.3	19.7	3.9
914.6(g)	waterbars placed diagonally	240	229	98.3	1.3	0.4
1038(b)(1)	permitted acts--ops on slopes>50%	240	3	100.0	0.0	0.0
1038(b)(2)	permitted acts--new trails >40%	239	3	100.0	0.0	0.0
914.2(c)	tractor roads minimized-#, width	240	237	96.2	3.4	0.4
914.2(d)	tractor ops avoided unstable soils	240	160	99.4	0.6	0.0
914.2(e)	slash/debris placed to avoid class I or II	240	215	99.5	0.5	0.0
914.6(c)	waterbreak spacing = standards	241	236	84.3	11.0	4.7
914.6(c)	waterbreaks--100 ft intervals cable roads	241	127	95.3	2.4	2.4
914.6(e)	waterbreaks for natural channels	239	108	95.4	1.9	2.8
914.6(f)	waterbreaks -unrestricted discharge	240	229	97.8	1.7	0.4
914.6(g)	waterbreaks cut to minimum depth 6 in.	240	228	97.8	2.2	0.0
914.6(g)	waterbreaks have embankment of 6 in	239	227	96.9	2.6	0.4
914.7(c)(3)	appropriate ops for winter period	240	3	100.0	0.0	0.0
923.4(c)	waterbreaks maintained to divert water	240	225	92.4	7.1	0.4

Table A-3. Landings--implementation ratings for landings as a whole.

Rule No.	Description	Number of Observations	Number of Observations (1-4)	% Meets or Exceeds FPR	% Minor Departure	% Major Departure
923(g)	Minimize cut/fill on unstable areas	290	206	98.1	1.5	0.5
923.1(a)	>1/4ac, substantial excavation-shown on THP map	291	118	83.1	11.0	5.9
923.1(d)	Slopes>65% or 50% within 100ft-treat	288	14	92.9	7.1	0.0
923.1(f)	Adequate #s of drainage structures	288	267	89.5	9.0	1.5
923.5(a)	New--slopes>65%, sidecast minimized	288	4	75.0	25.0	0.0
923.5(f)(2,4)	Fill extending 20ft with access--treated	289	47	91.5	8.5	0.0
923.5(f)(5)	Fill removed—channel reformed correctly	288	3	100.0	0.0	0.0
923.6	Wet spots been rocked/treated	288	46	93.5	6.5	0.0
923.8(a)	Abandonment--blocked to vehicles	287	5	100.0	0.0	0.0
923.8(b)	Abandonment--stabilization of cuts/fills	287	5	100.0	0.0	0.0
923.8(e)	Abandonment--proper channel formed	287	2	100.0	0.0	0.0
923.8(e)	Abandonment--cut banks sloped back	287	2	100.0	0.0	0.0
923.8(e)	Where fill removal infeasible-overflow channel	287	1	100.0	0.0	0.0
923.8	Abandonment-min. concentration of runoff	288	5	60.0	40.0	0.0
923.5(d)	Min. size consistent with yarding system	289	288	95.5	4.5	0.0
923.5(f)(1)	Slopes>65% or 50% within 100ft-treat edge	288	13	92.3	7.7	0.0
923.5(f)(2)	Ditches clear of obstructions	287	172	95.3	4.7	0.0
923.5(f)(3)	Sloped/ditched to prevent erosion	288	271	95.6	4.1	0.4
923.5(f)(5)	Sidecast/fill across watercourse pulled	288	2	100.0	0.0	0.0
923.5(f)(5)	Fill removed—cut banks sloped back	288	3	66.7	33.3	0.0
923.8(c)	Abandonment--grading for water dispersal	287	5	60.0	40.0	0.0
923.8(d)	Abandonment--fill pulled to prevent discharge	287	4	75.0	25.0	0.0
923.8	Abandonment--maintenance free drainage	288	5	100.0	0.0	0.0

Table A-4. Landings--effectiveness ratings.

Surface Rilling and Gullying	Effectiveness Category Percent	Effectiveness Category
a. Rilling on Landing Surface	56.1	None
	43.2	<1 rill/100 ft (0-20%)
	0.7	>1 rill/20 ft (>20%)
b. Gullies on Landing Surface	66.2	None
	32.7	< 1 gully per 100 ft transect
	1.1	Some gullying (< 1 gully per 20 ft of transect)
	0	Gullying that exceeds 1 gully per 20 ft of transect
Surface Drainage		
a. Drainage Runoff Structure	72.1	No evidence of erosion from concentrated flow where drainage leaves landing surface
	22.5	Rills or gullies present but do not extend >20 ft below edge of landing
	5.4	Presence of rills or gullies which extend >20 ft below edge of landing
b. Sediment Movement	93.6	No evidence of transport to WLPZ
	4.9	Sediment transport in WLPZ but not to channel
	1.5	Evidence of sediment transport or deposition in channel
Landing Cut Slopes		
a. Rilling	90.7	No evidence of rills
	6.6	Rills present but do not extend to drainage structure or ditch
	2.7	Rills present and extend to drainage structure of ditch

b. Gullies	97.3	No evidence of gullies
	0.5	Gullies present but do not extend to drainage structure or ditch
	2.2	Gullies present and extend to drainage structure or ditch
c. Failures	92.2	Less than 1 cubic yard of material moved
	6.1	More than 1 cubic yard moved but it is not transported to drainage structure or ditch
	1.7	More than 1 cubic yard moved, some material transported to drainage structure or ditch
Landing Fill Slopes		
a. Rilling	86.2	No evidence of rills
	13.4	Rills present but do not extend to drainage channels below toe of fill
	0.4	Rills present and extend to drainage channel below toe of fill
b. Gullies	88.5	No evidence of gullies
	10.6	Gullies present, but do not extend to drainage channels below toe of fill
	0.9	Gullies present and extend greater than a slope length below toe of fill
c. Slope Failures	94	No material moved
	4.6	Less than 1 cubic yard moved
	0.9	More than 1 cubic yard moved but does not enter channel
	0.5	More than 1 cubic yard moved, some material enters channel
d. Sediment Movement	94.9	No evidence of transport
	3.2	Sediment deposition in WLPZ but not carried to channel
	1.9	Evidence of sediment transport to or deposition in channel

Table A-5. Crossings--implementation ratings for crossings as a whole.

Rule No.	Description	Number of Observations	Number of Observations (1-4)	% Meets or Exceeds FPR	% Minor Departure	% Major Departure
923.4(d)	trash racks installed where needed at inlets	249	30	86.7	6.7	6.7
914.8(d)	tractor crossing--cut bank sloped back from channel	249	14	100.0	0.0	0.0
923.3(c)	restricted passage of fish allowed	249	10	60.0	30.0	10.0
923.4(1)	trash racks installed where lots of LWD	249	39	82.1	12.8	5.1
923.4(f)	50-year flood flow requirement	255	187	95.2	3.7	1.1
923.8(c)	abandonment--grading of road for dispersal	249	29	93.1	3.4	3.4
923.8(d)	abandonment--pulling/shaping of fills	249	30	83.3	6.7	10.0
923.8(e)	abandonment--fills excavated to reform channel	249	28	92.9	3.6	3.6
923.8	abandonment—minimize concentration of runoff	249	31	80.6	12.9	6.5
914.8(d)	tractor crossing--fills removed to reform channel	250	14	92.9	7.1	0.0
923.2(d)	fills across channels built to minimize erosion	164	120	82.5	10.8	6.7
923.2(e)	throughfills built in one-foot lifts	165	12	83.3	8.3	8.3
923.2(h)	size, #, location of structures okay to carry runoff	164	155	95.5	1.3	3.2
923.2(h)	size, #, location of structures minimizes erosion	164	155	87.7	6.5	5.8
923.2(h)	size,#,location of structures-nat.drainage pattern	164	155	96.8	2.6	0.6
923.2(o)	no discharge on fill unless energy dissipators	165	155	79.4	13.5	7.1
923.3(d)(1)	removed--are fills excavated to reform channel	249	31	80.6	16.1	3.2
923.3(d)(2)	removed--cut bank sloped back to stop slumping	249	31	83.9	9.7	6.5
923.3(e)	crossing/fills built to prevent diversion	249	206	85.9	10.7	3.4
923.4(c)	waterbreaks maintained to divert into cover	163	132	86.4	12.9	0.8
923.4(d)	crossing open to unrestricted passage of water	249	238	87.0	9.7	3.4
923.4(n)	crossing/approaches maintained to avoid diversion	249	205	83.4	14.1	2.4
923.4	trash racks in place as specified in THP	250	33	93.9	6.1	0.0
923.8(b)	abandonment--stabilization of exposed cuts/fills	249	29	82.8	10.3	6.9
923.8(e)	abandonment--cutbanks sloped back	249	28	92.9	0.0	7.1
923.8(e)	removal not feasible--diversion potential handled	247	9	88.9	0.0	11.1
923.8	abandonment--maintenance free drainage	249	31	96.8	0.0	3.2

Table A-6. Crossings--effectiveness ratings.

Fill Slopes at Crossings	**Effectiveness Category Percent**	**Effectiveness Category**
a. Vegetative Cover	68.1	Vigorous dense cover or fill slope of stable material
	23.6	Less than full cover, but >50% if fill slope has effective cover
	8.3	<50% of fill slope has effective cover
b. Rilling	78.6	Rills may be evident, infrequent, stable and no evidence of sediment delivery
	13.5	Few rills present (<1 rill per lineal 5 ft) not enlarging with little apparent deposition
	7.9	Numerous rills present (>1 rill per lineal 5 ft) enlarging or with evidence of delivery to channel
c. Gullies	86.9	None
	7.1	Gullies present, not enlarging, little apparent deposition in channel
	6	Gullies present and enlarging or threatening integrity of fill
d. Cracks	89.2	None evident
	8	Cracks present, but appear to be stabilized
	2.8	Cracks present and widening, threatening integrity of fill
e. Slope Failure	61.4	None
	32.1	Less than 1 cubic yard of material
	2.8	>1 cubic yard of material
	3.7	>1 cubic yard moved and material enters stream
Road Surface Draining to Crossings		
a. Rutting	83.3	No ruts present
	14.3	Some ruts present but design drainage not impaired
	2.4	Rutting impairs road drainage
b. Rilling	89.4	Little or no evidence of rilling
	8.6	Rills occupy <10% of road surface area, or do not leave road surface
	2	Rills occupy >10% of surface and continue off road surface onto crossing or fill
c. Ponding	82.6	No evidence of ponded water
	14.1	Ponding present, but does not appear to threaten integrity of fill
	3.3	Ponding present and is causing fill subsidence or otherwise threatening integrity of fill
d. Road Surface Drainage	63.9	Stable drainage with little or no sediment delivery to stream
	26.5	Slight sediment delivery but configuration is stable or stabilizing
	9.6	Continuing sediment delivery to stream and configuration is unstable/degrading

Culverts		
a. Scour at Inlet	92	No evidence of scour
	5.7	Scour evident but extends less than 2 channel widths above inlet and no undercutting of crossing fill
	2.3	Scour evident that extends more than 2 channel widths above inlet or scour is undercutting crossing fill
b. Scour at Outlet	63.8	No evidence of scour
	23	Scour evident, but extends less than 2 channel widths below outlet, and no undercutting of crossing fill
	13.2	Scour evident that extends more than 2 channel widths below outlet or scour undercuts crossing fill
c. Diversion Potential	83.5	Crossing configured to minimize fill loss (road does not slope downward from crossing in at least one direction)
	11	Crossing has road that slopes downward in at least one direction with drainage structure
	5.5	If culvert fails, flow will be diverted out of channel and down roadway
d. Plugging	78.2	No evidence of sediment, debris
	12.6	Sediment and/or debris is accumulating <30% of inlet or outlet is blocked
	9.2	Sediment and/or debris is blocking >30% of inlet or outlet
e. Piping	97.7	No evidence of flow beneath or around culvert
	2.3	Flow passes beneath or around culvert, or piping erosion evident
Non-Culvert Crossing		
a. Diversion	100	Crossing is configured to minimize fill loss
	0	Overflow will be diverted down roadway
Removed or Abandoned		
a. Bank Stabilization	61	Vigorous dense vegetation cover or other stabilization material
	34.1	Less than full cover, but >50% of channel bank has effective cover or has stable material
	4.9	<50% of channel bank has effective cover or is composed of stable material
b. Rilling of Banks	87.8	Rills may be evident but infrequent, stable, with no sediment delivery to channel
	12.2	Few rills present (<1 per lineal 5 ft) and rills not enlarging
	0	Numerous rills present (>1 rill per lineal 5 ft) or apparently enlarging
c. Gullies	100	None evident
	0	Gullies present but not enlarging
	0	Gullies present and enlarging or threatening integrity of fill
d. Slope Failures	97.6	Less than 1 cubic yard of material
	2.4	>1 cubic yard of material moved, material enters stream
	0	>=1 cubic yard of material moved but does not enter stream

e. Channel Configuration	80.5	Wider than natural channel and close to natural watercourse grade and orientation
	14.6	Minor differences from natural channel in width, grade, or orientation
	4.9	Narrower than natural channel width, or significant differences from natural channel grade or orientation
f. Excavated Material	92.5	Sloped to prevent slumping and minimize erosion
	7.5	Slumps or surface erosion present, but <1 cubic yard of material enters channel
	0	Slumps or surface erosion present, >1 cubic yard of material enters channel
g. Grading and Shaping	80	No evidence of erosion or sediment discharge to channel due to failures of cuts, fills or sidecast
	20	<1 cubic yard of material transported to channel due to failures of fills or sidecast
	0	>1 cubic yard material transported to channel due to failures of fills or sidecast
<u>Road Approaches at Abandoned Crossings</u>		
a. Grading and Shaping	76.5	No evidence of concentrated water flow to channel from road surface
	20.6	<1 cubic yard of material transported to channel from eroded surface soil on road approaches
	2.9	>1 cubic yard of material transported to channel from eroded surface soil on road approaches

Table A-7. WLPZs--implementation ratings for WLPZs as a whole.

Rule No.	Description	Number of Observations	Number of Observations (1-4)	% Meets or Exceeds FPR	% Minor Departure	% Major Departure
916.4(b)	THP provided for filtration of organic material	263	258	100.0	0.0	0.0
916.2(a)(4)	Sensitive conditions--overflow channels	264	84	100.0	0.0	0.0
916.4(b)	THP provided for flow changes by LWD	263	252	100.0	0.0	0.0
916.2(a)(4)	Sensitive conditions--flood prone areas	264	77	100.0	0.0	0.0
916.3(c)	Roads, landings outside of WLPZs	264	224	98.2	1.3	0.4
916.3(e)	Trees in WLPZ felled away from channel	264	238	97.5	2.5	0.0
916.4(a)	Sensitive conditions--erodible banks	264	111	89.2	9.0	1.8
916.4(a)	Sensitive conditions--changeable channels	264	89	98.9	1.1	0.0
916.4(b)(4)	WLPZ width segregated by slope class	264	235	97.4	2.6	0.0
916.4(b)(5)	No reduction in width with unrocked roads in WLPZ	264	3	100.0	0.0	0.0
916.4(b)(6)	75% surface cover retained in WLPZ	264	252	100.0	0.0	0.0
916.4(b)	THP provided for protection for water temp.	262	258	99.2	0.8	0.0
916.4(b)	THP provided for channel stabilization	264	251	98.8	1.2	0.0
916.4(d)	Heavy equip excluded unless explained	264	246	97.2	2.4	0.4
916.4(b)	THP provided for upslope stability	264	258	97.7	2.3	0.0
916.5(a)(3)	Side slope classes used to determine WLPZ	263	254	97.2	2.4	0.4
916.5(e)"D"	Class I-base mark applied below cut line	265	56	100.0	0.0	0.0
916.5(e)"F"	Class IV-when required in THP-trees marked	264	1	100.0	0.0	0.0
916.5(e)"F"	Class III-when required in THP-trees marked	264	3	100.0	0.0	0.0
916.5(e)"H"	Class III-50% of understory vegetation left in WLPZ	264	3	100.0	0.0	0.0
916.5(e)"I"	Class II-50% of total canopy left in WLPZ	264	203	96.6	2.5	1.0
916.5(e)"I"	Class IV-50% of total canopy left in WLPZ	264	3	100.0	0.0	0.0
916.7(b)	Where 800 sq ft exposed--replanting?	263	1	100.0	0.0	0.0
916.7, 916.7(b)	Where 800 sq ft exposed--grass seeding	264	8	100.0	0.0	0.0
916.7	Where 800 sq ft exposed--rip rap	264	1	100.0	0.0	0.0
916.2(a)(4)	Sensitive conditions-debris jam potential	263	98	98.0	2.0	0.0

916.2(a)(4)	Sensitive conditions--unstable banks	264	107	98.1	0.9	0.9
916.2(a)(4)	Sensitive conditions--existing roads in WLPZ	264	71	90.1	7.0	2.8
916.3(d)	Vegetation by wet areas retained/protected	264	113	100.0	0.0	0.0
916.3(d)	Soil within meadows/wet areas protected	264	98	100.0	0.0	0.0
916.3(g)	Class I/II-2 living conifers 16 in DBH, 50 ft tall	264	255	99.2	0.8	0.0
916.3.b	Accidental depositions of soil removed	264	34	94.1	5.9	0.0
916.4(a)	Sensitive conditions--existing roads in WLPZ	267	70	91.4	5.7	2.9
916.4(a)	Sensitive conditions--debris jam potential	264	96	95.8	4.2	0.0
916.4(a)	Sensitive conditions--overflow channels	264	83	100.0	0.0	0.0
916.4(a)	Sensitive conditions-flood prone areas	264	74	100.0	0.0	0.0
916.4(b)(3)	Width of WLPZ conform to Table 1 in FPRs	264	251	92.8	6.4	0.8
916.4(b)(5)	For I/IIs, where WLPZ reduced--still 50 ft wide	264	22	95.5	4.5	0.0
916.4(b)(5)	No WLPZ reduction when unrocked road	264	3	100.0	0.0	0.0
916.4(b)	WLPZ widths as wide as specified in Table 1	264	251	93.6	5.6	0.8
916.4(c)(2)	Class III/IV--measures in Table 1 applied	264	5	100.0	0.0	0.0
916.4(c)(3)	Class III-soil removed or stabilized	264	1	100.0	0.0	0.0
916.4(c)(3)	Temporary crossings removed	264	30	96.7	0.0	3.3
916.4(d)(1)	Class I-location of equipment flagged in WLPZ	264	8	100.0	0.0	0.0
916.5(a)(1)	Location of watercourse used to set WLPZ	271	269	98.5	1.5	0.0
916.5(a)(2)	Restorable beneficial uses used to set WLPZ	265	262	99.6	0.4	0.0
916.5(e)"E"	Class II-base mark below cut line of trees	264	181	98.3	1.1	0.6
916.5(e)"G"	Class I-50% overstory and 50% understory	264	59	100.0	0.0	0.0
916.7(b)	Stabilization 800 sq ft-improve sediment filter	264	10	100.0	0.0	0.0
916.7(b)	Stabilization 800 sq ft-minimize erosion	264	10	100.0	0.0	0.0
916.7(b)	Stabilization 800 sq ft-stabilize banks	264	10	100.0	0.0	0.0
916.7, 916.7(b)	Where 800 sq ft exposed-mulching	264	9	100.0	0.0	0.0
916.7	Stabilization 800 sq ft-prevent soil movement	264	8	100.0	0.0	0.0
916.2(a)(4)	Sensitive conditions--changeable channels	264	87	98.9	1.1	0.0
916.5(b)	Beneficial uses consistent w/WLPZ classes	263	260	98.8	1.2	0.0

Interagency Mitigation Monitoring Program
Pilot Project Final Report

September 2008

California Resources Agency
California Environmental Protection Agency
Central Valley Regional Water Quality Control Board
North Coast Regional Water Quality Control Board
California Department of Fish and Game
California Department of Forestry and Fire Protection
California Geological Survey

Arnold Schwarzenegger
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[1] The State Board of Forestry and Fire Protection's Monitoring Study Group (MSG) and its subcommittees are composed of members from the public, state and federal resource agencies, and the timber industry. Each agency and organization is responsible for determining the appropriate person(s) to serve as a representative on the MSG and its subcommittees (i.e., the Board does not make formal appointments).

[2] Subcommittee members with asterisks following their names participated as Coast or Inland team members collecting pilot project field data during 2006 and/or 2007. Some of the listed IMMP Subcommittee members did not participate throughout the entire three year pilot project program (March 2005 through June 2008). Several additional people participated to a limited degree.

[3] The Board and Monitoring Study Group recognize the contributions to the pilot project made by Palma Risler of the US EPA. Ms. Risler passed away on June 21, 2008 in San Francisco.

EXECUTIVE SUMMARY

The California Department of Forestry and Fire Protection (CAL FIRE) and the State Board of Forestry and Fire Protection (Board) have supported several monitoring projects over the past decade to evaluate the implementation and effectiveness of the California Forest Practice Rules. This monitoring work has provided considerable information on the effects of timber harvesting related to water quality. Data have been collected from randomly selected Timber Harvesting Plans (THPs) and locations within plans. Overall, rule implementation rates were reported to be high and erosion features were usually associated with improper application of the rules. Additionally, these monitoring programs found that there was a need for improved implementation of practices on forest roads, particularly at or near watercourse crossings.

The public and other resource agencies have expressed skepticism about these monitoring conclusions in the past, largely due to the monitoring methods used (including random site selection) and lack of direct participation in data collection. To address these concerns and increase cooperation between agencies, in the fall of 2004 CAL FIRE proposed using a multi-agency team approach that included all the Review Team agencies in the collection of monitoring data. Following agreements to participate by the Resources Agency and the California Environmental Protection Agency, the Interagency Mitigation Monitoring Program (IMMP) Subcommittee of the Board's Monitoring Study Group was formed in the spring of 2005 to develop the new program. The IMMP Subcommittee is composed of a diverse group of state agency personnel, landowner representatives, and the public. It includes representatives from the Department of Fish and Game (DFG), California Geological Survey (CGS), the North Coast Regional Water Quality Control Board (NCRWQCB), and the Central Valley Regional Water Quality Control Board (CVRWQCB), as well as CAL FIRE.

The IMMP Subcommittee established the following goals for the program: (1) to develop a forum for cooperation and to promote information sharing among interagency team members; (2) to develop and test repeatable protocols for field data collection to evaluate the effectiveness of practices; and (3) to test the interagency team approach as a mechanism for enabling state agencies to work together productively and for widely distributing monitoring conclusions.

A pilot project was conducted from 2005 to 2008 to develop a methodology and make needed refinements prior to implementing the long-term program. The pilot focused on watercourse crossings and the road segments that drain to crossings, since past monitoring work has shown that these are particularly high risk sites for sediment delivery to watercourses. The pilot project field work was conducted by two IMMP teams, with one team working in the Coast Range, headquartered in Santa Rosa, and the other working in the interior portion of the state and headquartered in Redding. Each team had one representative from each of the four Review Team agencies.

Field protocols were evaluated on 54 watercourse crossings selected from 22 plans on non-federal timberlands in California in 2006 and 2007. Watercourse crossings for the pilot project were selected based on screening criteria that included the types of practices used for watercourse crossing construction, identified beneficial uses of water present, slope, soil types, geologic considerations, and/or design and mitigation needed for complex conditions. This was not a random sample. Field work emphasized performance-based effectiveness evaluations after at least one wintering period for practices applied at or near watercourse crossing sites within a plan that were thought to pose a high risk to water quality. The pilot project work focused on the effectiveness of practices currently being utilized on plans, and not on specific regulatory requirements or violations that could result in legal/enforcement actions.

To expedite the pilot program, the IMMP Subcommittee adapted a portion of the Best Management Practices (BMP) Monitoring Protocol developed by the U.S. Forest Service for 12 northeastern states. The IMMP Subcommittee found this approach to be a transparent, repeatable, standardized monitoring method emphasizing performance-based evaluation of practices that could help achieve stated pilot project goals. While the USFS BMP approach proved to be a valuable model for developing pilot program protocols, field testing of the USFS BMP monitoring protocol during 2006 revealed that it does not apply well to California watersheds, included questions related to BMPs not relevant to this state, and does not include questions related to California forest practices.

To address these problems, numerous additional “California-specific” questions were added to the USFS BMP protocol, as well as a set of subjective questions used to promote consensus among all the agency team members. Following the 2006 field season, the two pilot project teams merged the USFS BMP monitoring protocol, California-specific questions, and subjective questions, forming a new “California watercourse crossing protocol.” This revised protocol consists of 270 questions, including general questions; questions regarding both road approaches to the crossing, the crossing structure, water drafting areas; and summary questions. In most cases, fewer than half of the questions are answered at a single site, since many do not apply to the crossing being evaluated. Usually three to four crossings can be evaluated per day (45 minutes to two hours per crossing). Detailed field guidelines and a photographic log were developed, as well as a relational database to store watercourse crossing data.

Changes in pilot project protocols during and between the two phases of the pilot project limited data entry, analysis, and conclusions that can be made from the overall data set. Therefore, general findings from the pilot are presented in this report rather than specific data results. These findings include:

(1) A protocol for evaluating practice effectiveness at and near watercourse crossings in California has been successfully developed;
(2) While tedious to use, the protocol forced team members to be objective and reach consensus;

(3) The pilot project was an effective team building exercise—demonstrating that the Review Team agencies can work together cooperatively and achieve consensus;
(4) Virtually all crossings and/or road approaches to crossings deliver some sediment (i.e., "trace" amounts) to watercourses, even when the rules and additional THP measures are properly applied;
(5) Improper installation and/or maintenance of crossings and drainage structures near crossings, and improper crossing removal, are major causes of sediment movement and deposition;
(6) Road approaches near crossings produce a high percentage of sediment transport/deposition problems;
(7) Photographic logs are extremely valuable in documenting effectiveness of practices;
(8) The pilot project was a beneficial training exercise that developed skills necessary for evaluating watercourse crossing and road approach performance;
(9) The IMMP approach for problem solving should be continued, but not be limited to watercourse crossings; and
(10) Better practice implementation can be achieved with improved Licensed Timber Operator (LTO) training, and more active and post-active multi-agency inspections.

The main recommendations from the pilot program focus on using the California watercourse crossing protocol as a **multi-agency training tool** to help field personnel recognize critical situations during field inspections. The IMMP Subcommittee recommends that the protocol be used as a mandatory Review Team training tool, where agency staff are rotated into regional teams on a regular basis to prevent staff "burn-out." Quality assurance/quality control (QA/QC) oversight team(s) will be needed to verify data accuracy and consistent application of the protocol. Additional recommendations include securing adequate funding to allow the program to continue, obtaining long-term database assistance, using the field teams to refine and test additional monitoring protocols selected by the IMMP Subcommittee, and continuing outreach to landowners, Registered Professional Foresters, and LTOs based on monitoring results.

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LIST OF ABBREVIATIONS

BMPs	Best Management Practices
BOF/Board	California State Board of Forestry and Fire Protection
CAL FIRE	California Department of Forestry and Fire Protection
CFA	California Forestry Association
CGS	California Geological Survey
CLFA	California Licensed Foresters Association
CRA	California Resources Agency
CSES	Critical Sites Erosion Study
CVRWQCB	Central Valley Regional Water Quality Control Board
DFG	California Department of Fish and Game
ECMP	Erosion Control Maintenance Period
EHR	Erosion Hazard Rating
ELZ	Equipment Limitation Zone
FLOC	Forest Landowners of California
FORPRIEM	Forest Practice Rule Implementation and Effectiveness Monitoring
FPA	Forest Practice Act
FPRs	Forest Practice Rules
GPS	Global Positioning System
HMP	Hillslope Monitoring Program
IMMP	Interagency Mitigation Monitoring Program
KREW	Kings River Experimental Watershed Study
LTO	Licensed Timber Operator
MCR	Modified Completion Report Monitoring
MOU	Memorandum of Understanding
MSG	Monitoring Study Group
NTMP	Nonindustrial Timber Management Plan
NCRWQCB	North Coast Regional Water Quality Control Board
PDA	Personal Digital Assistant (pocket computer)
PHI	Pre-Harvest Inspection
PMP	Pilot Monitoring Program
QA/QC	Quality Assurance/Quality Control
RPF	Registered Professional Forester
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board
THP	Timber Harvesting Plan
US EPA	U.S. Environmental Protection Agency
USFS	U.S. Department of Agriculture, Forest Service
WDRs	Waste Discharge Requirements
WLPZ	Watercourse and Lake Protection Zone

INTRODUCTION

Background Information

This report summarizes findings of the Interagency Mitigation Monitoring Program (IMMP) pilot project conducted from March 2005 through June 2008. Work on the IMMP has been directed by a subcommittee of the State Board of Forestry and Fire Protection's Monitoring Study Group (MSG), composed of individuals from the resource agencies, the timber industry, and the public. Primary goals of the IMMP have been to reach agreement on monitoring methods and to improve agency communication.

The IMMP pilot project promoted agency consensus on the development and use of monitoring methods to be used in a full scale monitoring program, as recommended by MacDonald (1994). The IMMP Subcommittee determined that the pilot should be focused on watercourse crossings and road segments draining to crossings (Figure 1), since past monitoring and research work has shown that these are particularly high risk sites for sediment delivery to watercourse channels (Pyles and others 1989, Wemple and others 1996, Furniss and others 1998, BOF 1999, Cafferata and Munn 2002, Bundros and others 2003, MacDonald and others 2004, USFS 2004, Coe 2006, Brandow and others 2006).

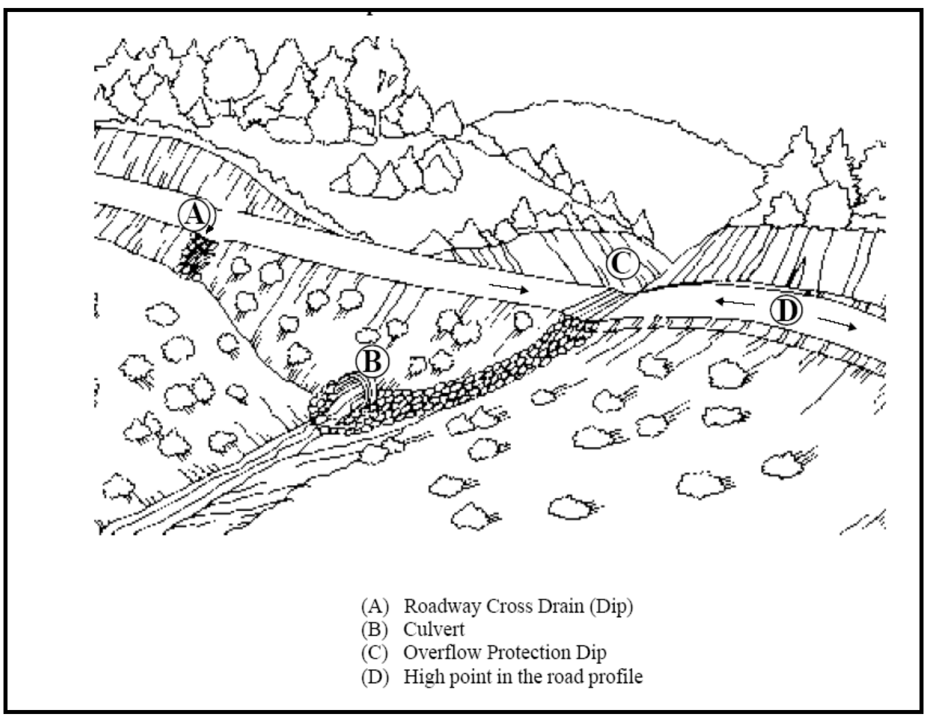

Figure 1. Diagram of a watercourse crossing and road segments draining to the crossing. Figure 7.11 in Keller and Sherar 2003.

The pilot project work was conducted by two IMMP field teams, one working out of Santa Rosa (Coast team) and the other headquartered in Redding (Inland team). The Coast team evaluated crossings in the Coast Range, while the Inland team examined crossings in the interior portion of the state (i.e., Klamath Mountains, Cascade Range, and northern Sierra Nevada). This report includes findings and recommendations for future monitoring protocols, but does not include data or results from field evaluations of individual watercourse crossings. Changes in pilot project protocols during and between the two phases of the pilot project limited data entry, analysis, and conclusions that can be made from the overall data set.

Past Water Quality Monitoring Projects and Their Relation to the IMMP

The California Department of Forestry and Fire Protection (CAL FIRE) and the California State Board of Forestry and Fire Protection (Board) have recognized the importance of implementation and effectiveness monitoring to determine whether the Forest Practice Rules (FPRs) and the Timber Harvesting Plan (THP) review process adequately protect the beneficial uses of the state's waters since the mid-1980's. The earliest monitoring project, implemented as a cooperative project by the Board, CAL FIRE, the California Department of Fish and Game, and the State Water Resources Control Board, was a qualitative assessment of 100 non-randomly selected THPs conducted on non-federal timberlands in 1986 by a team of four resource professionals (i.e., the "208 Study"). This effort found that the FPRs were generally effective when properly implemented on terrain that was not overly sensitive (i.e., areas without highly erodible soils or elevated mass wasting potential), and that inadequate rule implementation was the most common cause of water quality impacts. Poor road location, construction, drainage and/or removal were noted as common reasons for significant adverse impacts (CSWRCB 1987). Results from this monitoring project were used by the Board to modify the FPRs for water quality protection (Johnson 1993).

Further monitoring was required, however, as a condition of having the FPRs certified as Best Management Practices (BMPs) by the U.S. EPA (BOF 2007). Based on a strategy developed through the MSG, several hillslope and instream monitoring projects were implemented, beginning in the early 1990's. These efforts included the Pilot Monitoring Program (PMP) that operated from 1993 through 1995 to test procedures for hillslope and instream monitoring (Tuttle 1995, Rae 1995, Spittler 1995, Lee 1997). Following the completion of the PMP, a long-term monitoring program was initiated in 1996. This program has included several cooperative instream monitoring projects and two state-sponsored hillslope or onsite monitoring programs that were conducted from 1996 through 2004.

The Hillslope Monitoring Program (HMP) ran from 1996 to 2002, with data collected by independent contractors (BOF 1999, Cafferata and Munn 2002). The first phase of a Modified Completion Report (MCR) monitoring program was implemented by CAL FIRE from 2001 to 2004, using state Forest Practice Inspectors to collect onsite data as part of required Work Completion Report inspections (Brandow and others 2006). Results from these studies were similar and have been widely distributed to state and federal agencies, timberland owners, and the public. In general, implementation rates of California's water quality-related FPRs were found to be high (>90 percent), which is similar to findings of studies in other western states (Ice and others 2004, Ice and Schilling 2007, CWSF 2007). The California studies also reported that erosion features were usually associated with improper application of the rules, and that individual practices required by the Rules were effective in preventing hillslope erosion features when properly implemented.

On randomly selected high risk sites (i.e., roads, landings, skid trails, crossings, and Watercourse and Lake Protection Zones) found within the randomly sampled THPs, most of the water quality problems and sediment delivery sites were associated with roads and associated watercourse crossings. Watercourse crossings had the highest rate of problems, with significant implementation and/or effectiveness issues reported on approximately 20 percent of the randomly sampled crossings in both monitoring programs. These problems were mainly related to diversion potential, plugging, scour at the outlet, road drainage structure function near the crossing, and fillslope erosion.

The other main problem area was erosion from roads caused by improper design, construction, and maintenance of drainage structures. In the HMP, nearly half the randomly selected road transects had one or more rills present and approximately 25 percent had at least one gully. Evidence of sediment transport to a watercourse channel was found on approximately 13 percent and 25 percent of these rill and gully features, respectively, with high percentages of delivery to Class III watercourses (headwater channels). These erosion features were mostly caused by drainage feature deficiencies that were usually not in compliance with the FPRs (Cafferata and Munn 2002).[4] In the MCR study, erosion was found at more than 50 percent of the road-related features that were identified as departing from the FPRs, and evidence of sediment transport to channels was found at 11 percent of these sites. In contrast, erosion was found at five percent of the sites with acceptable FPR implementation, and evidence of sediment transport to a channel was observed only one percent of the time (Brandow and others 2006).

These past monitoring programs have clearly shown the need for improved implementation of practices on forest roads and at watercourse crossings to prevent adverse impacts to water quality. However, considerable skepticism has been expressed about the conclusion that properly implemented FPRs are generally effective in protecting beneficial uses of water in California (as well as in other western states) (Ice and others 2004). Reasons for such lack of confidence include the monitoring methods used by past studies (e.g., lack of information about both fine sediment delivery to watercourses during winter storms and in-unit mass wasting rates [Stillwater

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[4] More recent work by Coe (2006) showed that the majority of forest road sediment delivery from surface erosion processes occurs at or near watercourse crossings. Working in the central Sierra Nevada, he found that adequately maintained roads typically have smaller areas between drainage structures, which limits sediment production, and that when the Forest Practice Rules are properly implemented, sediment delivery is usually not an issue (BOF 2006).

Sciences 2002]); lack of multi-agency participation in the monitoring process; and the use of random sampling procedures that limited evaluation of less frequent “high risk” sites that are major sources of erosion and sediment.[5] Concerns have also been expressed about how monitoring results have been used in the public arena, as well as lack of public participation in monitoring programs and data collection. As a result, a new, more broadly-based monitoring approach was needed to address concerns about water quality impacts from timber operations at high risk sites.

Options for collecting onsite monitoring data on non-federal timberlands in California have been described by Tuttle (1995). They include using: (1) private consultants, (2) CAL FIRE Forest Practice Inspectors, (3) one or more multi-interdisciplinary teams of state agency staff, and (4) self-monitoring by landowners with or without state agency oversight. The HMP and MCR programs relied on options (1) and (2), respectively, and the Regional Water Quality Control Boards are currently using option (4) to monitor requirements of Region-specific Waivers of Waste Discharge Requirements (WDRs) or General WDRs for silvicultural activities.

The multi-interdisciplinary team approach has been used effectively in the past in California (e.g., the “208 Study”) and in other western states. For example, Montana has used interdisciplinary teams to monitor BMP implementation and effectiveness since 1990 (Ethridge 2004). Advantages provided by the designated multi-interdisciplinary team approach include a balance of interests among involved agencies and greater public confidence in monitoring results. In addition, trained staff can provide continuity in applying monitoring protocols. The main disadvantage is the relatively high cost of dedicating agency staff to multi-agency teams (Tuttle 1995).

Based on the need for greater acceptance of monitoring results and direction from the California Resources Agency for improved interagency cooperation, CAL FIRE proposed forming the Interagency Mitigation Monitoring Program (IMMP) in the fall of 2004. Following agreement by Department of Fish and Game (DFG), California Geological Survey (CGS), the North Coast Regional Water Quality Control Board (NCRWQCB), and the Central Valley Regional Water Quality Control Board (CVRWQCB) to participate in this new program, the first MSG IMMP Subcommittee meeting was held in March 2005. Prior to initiating field studies, a “general framework report” was prepared to document agreed-to IMMP concepts (CRA and others 2006). A timeline for the pilot project is presented in Figure 2.

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[5] Currently, information on fine sediment delivery during winter storm events related to forestry operations is being evaluated by cooperative instream monitoring projects, such as the Caspar Creek, Little Creek, Judd Creek, South Fork Wages Creek, and Kings River watershed studies. Regarding random sampling, MacDonald (2005) concluded that if the primary objective of a study is to evaluate the effectiveness of BMPs for protecting water quality, then the focus of sampling should be on sites that are at higher risk, rather than using a random sample. It is imperative, however, to know the proportion of high risk sites that occur in a population to extend results to the total population of high risk and other sites.

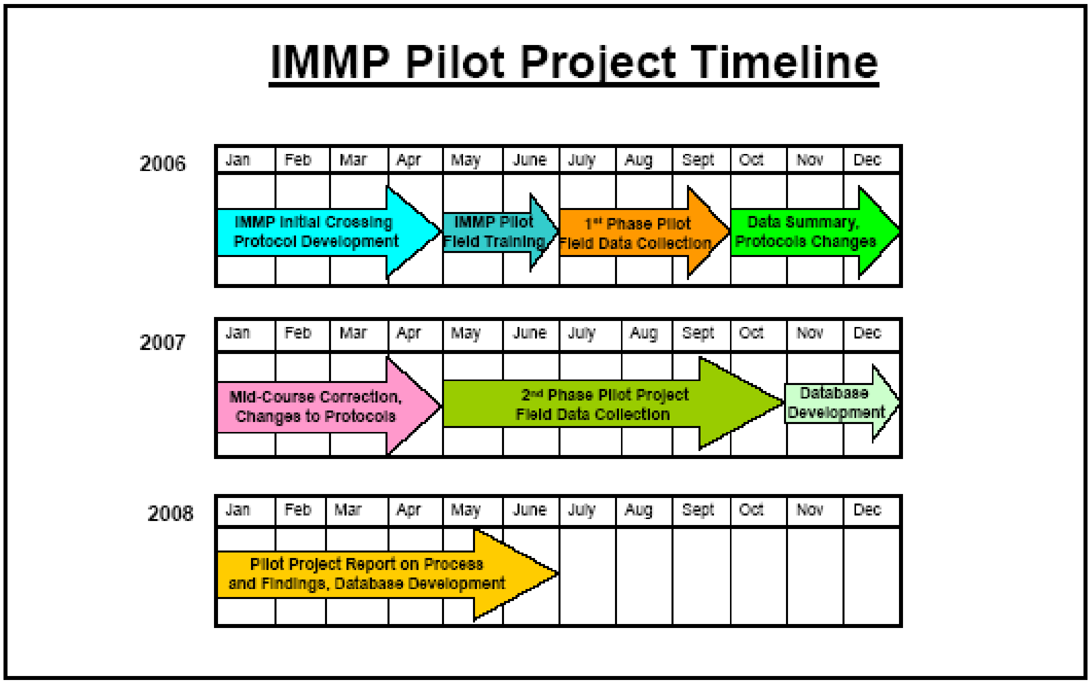

Figure 2. The pilot project timeline from January 2006 through June 2008.

IMMP Pilot Project Goals and Objectives

The primary goals of the pilot project were to: (1) provide a mechanism for interagency monitoring by the Review Team agencies, promoting increased cooperation between the agencies, and (2) develop a set of protocols for data collection on the effectiveness of practices that past monitoring has shown to be the most likely source of adverse impacts to water quality (i.e., watercourse crossings and road segments that drain to crossings). To implement these objectives, the pilot project focused on developing protocols for evaluating the effectiveness of practices used at higher risk (non-random) watercourse crossing sites.[6] Some lower risk crossings were included to test whether pre-determined high risk sites actually produce larger water quality impacts. The pilot project did not develop protocols to evaluate the implementation and effectiveness of individual FPRs related to forest roads and watercourse crossings, since this had previously been done by the HMP and MCR work (Cafferata and Munn 2002, Brandow and others 2006).

Specific objectives of the pilot project were to:

(1) Develop a forum for cooperation and to promote information sharing among interagency team members.

[6] Higher risk sites in plans related to water quality are usually in close proximity to watercourses and/or located on steeper, more erodible slopes. Specific criteria for higher risk sites are provided in the MOU Monitoring Workgroup (2005) document titled “Joint Report on Monitoring Terms and Authorities.”

(2) Develop and test repeatable protocols for field data collection to evaluate the effectiveness of practices implemented at watercourse crossings and road segments that drain to crossings (locations where there is a high risk of impact to water quality). Practices included FPRs, additional mitigation measures, and special plan requirements. The protocol developed should allow any user (agency representatives, landowners, etc.) to reach similar conclusions.

(3) Test the interagency team approach as a mechanism for enabling state agencies to work together productively and widely distribute monitoring conclusions.

PILOT PROJECT STUDY AREA

The study area for the pilot phase of the IMMP was located in northern California and was divided into two sub-units defined primarily by the participating agency districts (Figure 3). Site evaluations within each area were conducted by separate teams of agency representatives.

The Inland pilot project team was comprised of CGS's Northern Unit, DFG's Northern Region, the northern part of the RWQCB's Central Valley Region, and the Cascade component of CAL FIRE's Northern Region. These boundaries overlapped in Shasta and Tehama Counties, southeast Siskiyou County, southern through north-central Modoc County, and western through northern Lassen County.

The Coast team was comprised of the same CGS unit, DFG's Bay-Delta Region, the RWQCB's North Coast Region, and the coastal part of CAL FIRE's Northern Region. Overlapping districts included only portions of Sonoma, Napa, and Santa Cruz counties. To obtain a more representative sample of watercourse crossings, the Santa Rosa team extended its sample area within the boundaries of CAL FIRE's Coast Forest Practice District. This allowed Humboldt and Mendocino Counties to be added to the study area.

The field teams included members from each agency that participates in timber harvest review (CAL FIRE, CDFG, RWQCBs, and CGS). To promote interagency interaction, unbiased observations, cooperation, and information sharing, it was determined that no individual agency would assume control of the field work. Inland team members in 2006 were Shane Cunningham, CAL FIRE; Joe Croteau, DFG; Angela Wilson, CVRWQCB; and Dave Longstreth, CGS. In 2007, Stacy Stanish replaced Joe Croteau as the DFG team representative. Coast team members in 2006 were Anthony Lukacic, CAL FIRE; Richard Fitzgerald, DFG; Dave Hope, NCRWQCB; and Dave Longstreth, CGS (Figure 4). In 2007, Suzanne DeLeon replaced Richard Fitzgerald as the DFG team representative.

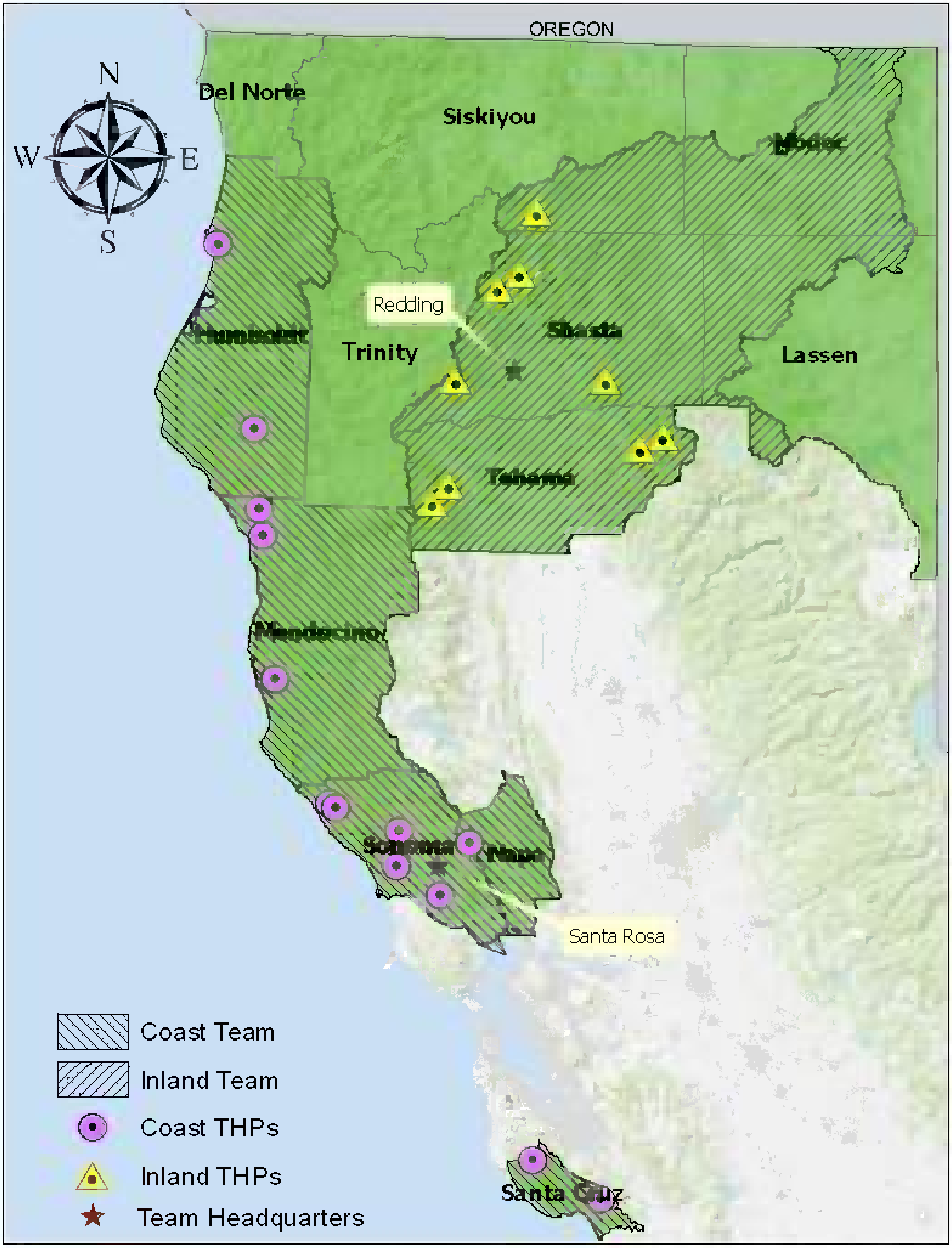

Figure 3. Map displaying locations of 22 plans sampled as part of the pilot project during 2006 and 2007.

Figure 4. Pilot project Coast team during 2006, comprised of Dave Longstreth, CGS, Anthony Lukacic, CAL FIRE, Dave Hope, NCRWQCB, and Richard Fitzgerald, DFG.

PROTOCOL DEVELOPMENT AND METHODS

The pilot project consisted of the development of procedures that evaluate effectiveness of practices prescribed for perceived “high risk” watercourse crossings. The various approaches tested in the pilot are described in the sections below.

Crossing Selection Procedure

One of the main complaints about previous monitoring efforts was the infrequent evaluation of higher risk sites that resulted from use of random sampling, which limited sample size of these less frequent, but very important, potential erosion sites. To overcome this limitation, IMMP Subcommittee members have stated that the effectiveness of the FPRs must be evaluated at worst-case scenarios (i.e., “high risk” locations).[7]

Contributing factors that can be used to categorize “risk” at a watercourse crossing are many, and may include the following (and their relationships to one another) (see MOU Monitoring Workgroup 2005 for a more detailed list of factors):

- Underlying geology, unstable soils
- Watercourse classification
- Channel morphology
- Road approach conditions
- Side slope steepness
- Proposed use of the crossing
- Ease of access for maintenance
- Beneficial uses of water in and downstream of adjacent watercourses (aquatic organisms, threatened or impaired species, domestic supply, etc.)
- Past flow events
- Topography
- Elevation (area of rain-on-snow events)
- Precipitation levels
- High and Extreme erosion hazard rating (EHR)

To address these concerns, watercourse crossings in the pilot project were selected using agency knowledge of proposed and/or existing crossings that appeared difficult and/or complex to install, repair, upgrade, or remove because of existing conditions, which were assumed to pose the greatest chance of performance problems and sediment delivery.

[7] Use of non-randomly selected sites is supported by past studies, which have shown that a small percentage of a road network produces most of the hillslope erosion (McCashion and Rice 1983, Durgin and others 1989) and a small percentage of decommissioned or upgraded watercourse crossings produce most of the sediment input to streams (Klein 2003, PWA 2005, Keppeler and others 2007, Harris and others 2008).

THPs submitted by both large and small timberland owners were included in the pilot program. Selected sites generally had been through at least one winter period following installation, upgrading, or removal of watercourse crossings and the installation of road drainage structures, but were still within the Erosion Control Maintenance Period (ECMP). Crossings on Class I, II, and III watercourses were included in the pilot work, as were all types of watercourse crossings (e.g., culverts, fords, bridges, removed crossings, etc.).

The resulting sample did not provide a basis for reaching conclusions about all crossings. It did, however, provide an objective and repeatable approach for promoting interagency cooperation and interaction, and for addressing each agency's concerns. Because the resulting sample was limited to "high risk" crossings, a non-random method of evaluation was conducted. As such sampling was not conducted as a controlled experiment that would provide a "scientific" level of trial and evidence and does not provide a statistically valid basis for conclusions about all types of watercourse crossings (high risk and non-high risk). The goal of the pilot project was to provide an objective and repeatable approach for promoting interagency cooperation and interaction, and for addressing each agency's concerns regarding forest practices in California and their impacts to water quality.

An unanticipated complication from using a non-random sampling approach arose during the first phase of protocol development. During the THP review process, a "high risk" crossing is identified either by the Registered Professional Forester (RPF) or by the Review Team agencies. Consequently, the RPF/Plan Submitter and/or reviewing agencies often spend considerable effort in mitigating the site to effectively lower the perceived risk. Thus, a previously identified "high risk" crossing should, by the process of applying mitigations in addition to FPR requirements, result in a reduction of potential impacts. Subsequent review might then indicate that the site has not merited the "high risk" categorization. This could lead to a conclusion that resource professionals evaluating these sites are not correctly identifying potentially "high risk" crossings when, in fact, the mitigations applied to the crossing prevented or significantly reduced the threats that led to identification of the crossing in the first place.

Adaption and Modification of USFS BMP Monitoring Protocol

To expedite the pilot program, the IMMP Subcommittee adapted a portion of the Best Management Practices (BMP) Monitoring Protocol developed by the U.S. Forest Service for 12 northeastern states (Welsch and others 2007).[8] The IMMP Subcommittee found this approach to be a transparent, repeatable, standardized monitoring method emphasizing performance-based evaluation of effectiveness of practices that could help achieve stated pilot project goals. It was thought that use of the USFS protocol in California would produce data comparable with other states using the same protocol. Only those portions of the USFS BMP protocol that evaluated watercourse crossings and road approaches to crossings were used in the pilot project. Other sections of the

[8] Further description of the U.S. Forest Service BMP monitoring protocol are found in the following references: Ryder 2004, Ryder and Edwards 2005, and Ferrare and others 2007.

USFS BMP protocol that evaluated roads and landings in the buffer, riparian buffers, chemical pollution control, and wetlands were not used (136 out of 197 questions were answered).

Overarching Questions

Initial testing of the USFS BMP Monitoring Protocol suggested that it does not specifically address performance of California Forest Practice Rules and other Review Team agency concerns, primarily because it was developed outside of California. In order to address issues that were not covered by the USFS protocol, each agency developed key (overarching) questions that were needed to properly evaluate effectiveness of California Forest Practice Rules and impacts to water quality at or near watercourse crossings (summarized below, complete questions are included in CRA and others 2006).

- IMPLEMENTATION and EFFECTIVNESS of watercourse crossings in relation to requirements of current California Forest Practice Rules (FPRs) and additional Best Management Practices (BMPs).
- AQUATIC HABITAT PROTECTION in relation to watercourse crossing design, installation, and the California Department of Fish and Game 1600 Streambed Alteration Agreement process.
- FISH PASSAGE and DOWNSTREAM RESOURCE PROTECTION in relation to watercourse classification and crossing characteristics.
- PERFORMANCE OF CROSSING TYPES in relation to PHYSICAL SETTING FACTORS.
- GEOLOGY, GEOMORPHOLOGY, and SOIL CHARACTERISTICS in relation to mass wasting, erosion, and sediment delivery at watercourse crossings.

California Specific Questions

In order to address the overarching questions, each agency developed specific questions not already included in the USFS BMP monitoring protocol. Collectively, the agencies produced 54 questions in addition to those in the USFS protocol. These questions require observation of potential or actual causes of erosion and sediment delivery associated with watercourse crossings and their approaches. Examples of specific questions that were developed in response to overarching questions are provided below.

OVERARCHING QUESTION		SAMPLE OF SPECIFIC QUESTIONS
IMPLEMENTATION and EFFECTIVENESS of watercourse crossings in relation to requirements of current California Forest Practice Rules (FPRs) and additional BMPs.	→	Enter the code indicating if the size of the crossing structure opening meets state requirements at the time of plan approval. 1. Yes 2. No 3. Unknown Were principles / practices applied? 1. Yes 2. No Were measures employed that were over and above the requirements of the plan and/or Rules? 1. Yes 2. No Enter one or more codes that describe the plan requirements for the crossing site being evaluated. 1. Standard California Forest Practice Rules including the Threatened or Impaired Watersheds Rule Package (July 1, 2000) where appropriate. 2. Additional mitigation measures assigned during plan review were required and/or the RPF proposed additional measures, which were above and beyond the FPRs. 3. Exceptions, alternatives or in-lieu practices were proposed, which superseded the standard Forest Practice Rules.
AQUATIC HABITAT PROTECTION in relation to watercourse crossing design, installation and the California DFG Streambed Alteration Agreement (1600).	→	Is there a DFG 1600 agreement? 1. Yes 2. No 3. Unknown Have modifications been made to the crossing, for purposes such as water drafting, which have impacted the functionality of the crossing? 1. No 2. Yes 3. Yes (1600 agreement) 4. Unknown Enter the code indicating if there is evidence of stream downcutting, scouring, or aggradation within 100 feet downstream of the outlet end of the structure. 1. Evidence of scouring and downcutting. 2. Evidence of aggrading or widening. 3. Stable. Enter the code indicating if there is evidence of stream downcutting, scouring, or aggradation within 100 feet upstream of the inlet end of the structure. 1. Evidence of scouring and downcutting. 2. Evidence of aggrading or widening. 3. Stable.

OVERARCHING QUESTION		SAMPLE OF SPECIFIC QUESTIONS
FISH PASSAGE and DOWNSTREAM RESOURCE PROTECTION in relation to watercourse classification and characteristics.	→	See the questions below
PERFORMANCE OF CROSSING TYPES in relation to PHYSICAL SETTINGS FACTORS.	→	See the questions below

FISH PASSAGE and DOWNSTREAM RESOURCE PROTECTION in relation to watercourse classification and characteristics. →

Is the pipe located on a Class I fish bearing watercourse?

1. Yes (go to C-125)
2. No (go to C-160)

Enter the code indicating depth of the residual pool at the inlet in inches.

1. < 6”
2. ≥ 6”

Enter the code indicating if there is streambed substrate throughout the pipe.

1. Yes
2. No

Enter the code indicating if the pipe includes baffles or weirs.

1. Yes
2. No

Enter the code indicating if there is a pool at the outlet.

1. Yes
2. No

Enter the code indicating pipe outlet drop in inches.

1. 0-11”, 2. 12-24”, 3. >24”

PERFORMANCE OF CROSSING TYPES in relation to PHYSICAL SETTINGS FACTORS. →

Is there perched fill material at the inlet or outlet of the crossing within or immediately adjacent to bankfull.

1. Yes
2. No

Enter the active channel bed width in feet (measured at a riffle).

Enter the bankfull channel width in feet (measured at a riffle).

Enter the bankfull depth in feet (measured at a riffle).

Enter the code best describing the entrenchment of the natural watercourse channel above the crossing.

1. Entrenched (Confined).
2. Moderately entrenched (Unconfined).
3. Slightly entrenched (Braided).

Enter the code best describing the average percent grade of the natural watercourse channel above and below the crossing.

1. 0-2%
2. 2-4%
3. 4-10%
4. 10-30%
5. > 30%

Enter the code indicating the approximate volume of sediment delivered to the watercourse based on volume of voids and/or measurable sediment deposits observed at the crossing and approaches.

1. No observed sediment
2. Trace to 1 cubic yard
3. 1-10 cubic yards
4. 11-50 cubic yards
5. 51-100 cubic yards
6. 101-500 cubic yards
7. 501-1000 cubic yards
8. Greater than 1000 cubic yards

OVERARCHING QUESTION		SAMPLE OF SPECIFIC QUESTIONS
GEOLOGY, GEOMORPHOLOGY, and SOIL CHARACTERISTICS in relation to mass wasting, erosion, and sediment delivery at watercourse crossings.	→	Enter the code for the Erosion Hazard Rating (EHR) listed in the plan for the crossing area. 1. Low, 2. Moderate, 3. High, 4. Extreme Enter the code indicating the specific underlying rock type/formation (the standard geologic formation letter symbology may be initially coded in). Enter the code indicating the type of mapped landslides under the site (pick one or more). 1. Active rockslide 2. Dormant rockslide 3. Active debris flow or debris slide 4. Dormant debris flow or debris slide 5. Active earthflow 6. Dormant earthflow 7. Inner Gorge 8. Debris slide slope 9. No mapped landslide Enter the code indicating if a recent landslide impacts the crossing. 1. Yes 2. No

California Subjective Questions

To achieve interagency interaction, cooperation, and normalization of observations, a series of summary questions were designed to query whether the interagency team members reached agreement on the overall performance of the crossing and approaches being studied. The questions ask the IMMP team members to reach a *subjective* conclusion about performance of the crossing and approaches, with the hope of developing a common point of view that can eventually be applied to other forestry topics. An example of one of these subjective questions is provided below in Figure 5.

Additionally, at the end of the questionnaire, the interagency team “graded” each crossing and its approaches (together) using a letter grading system. This was included as an intuitive grading system that the project IMMP participants were familiar with (A = Excellent, B = Good, C = Fair, D = Poor, F = Fail). The assigned letter grade is recorded in the pilot project protocol and on the photographic log discussed below. Grading the crossings and its approaches compelled the team members to discuss their opinions regarding the evaluation before reaching consensus.

Enter the appropriate rating for the crossing, utilizing the matrix provided below.

	Performing properly, no sign. sediment delivery problems	Performing properly, sediment is still being delivered	Performing properly, no sediment delivery, but there is potential	Not performing properly, sign. sediment delivery problems
Properly designed and constructed	1	2	3	4
Properly designed, not properly constructed	5	6	7	8
Not properly designed, constructed to design	9	10	11	12

Figure 5. California subjective crossing matrix used for the pilot project.

Structure of the California Watercourse Crossing Protocol

After field testing in 2006, the California specific and subjective questions (described above) were merged with the crossing portion of the USFS BMP monitoring protocol, forming a new "California watercourse crossing protocol" consisting of 270 questions (described below and provided in Appendix A). This revised protocol was field tested in 2007.

The California watercourse crossing protocol is divided into seven main categories:

- General Questions. Questions gathering information on landowners, THP number, crossing location, bedrock geology, watercourse classification, and other site information.

- Approach Areas A and B. Questions that evaluate design, implementation, and performance of the road approach on the left side of the crossing when looking downstream ("A Side Approach") and on the right side of the crossing when looking downstream ("B Side Approach") (Figure 6). The approaches are further divided into the portions of the approaches that are outside and inside of the Watercourse and Lake Protection Zone (WLPZ)/Equipment Limitation Zone (ELZ) (i.e., areas of increased watercourse protection as defined in the FPRs).

* Water Drafting Areas A and B. Questions that evaluate implementation, design, and performance of water drafting sites on either side of the crossing.

* Crossing Structure. Questions evaluating implementation, design, and performance of the crossing structure itself.

* Summary Questions. Subjective questions requiring field crew members to formulate conclusions based on cumulative knowledge and opinion developed during discussion and response to the numerous objective questions in the monitoring protocol. These questions query overall performance (implementation, design, and observed direct or potential sediment delivery) of the crossing and its approaches. Additionally, a letter grade is assigned to the crossing and its approaches. Responses are based on consensus among field crew participants.

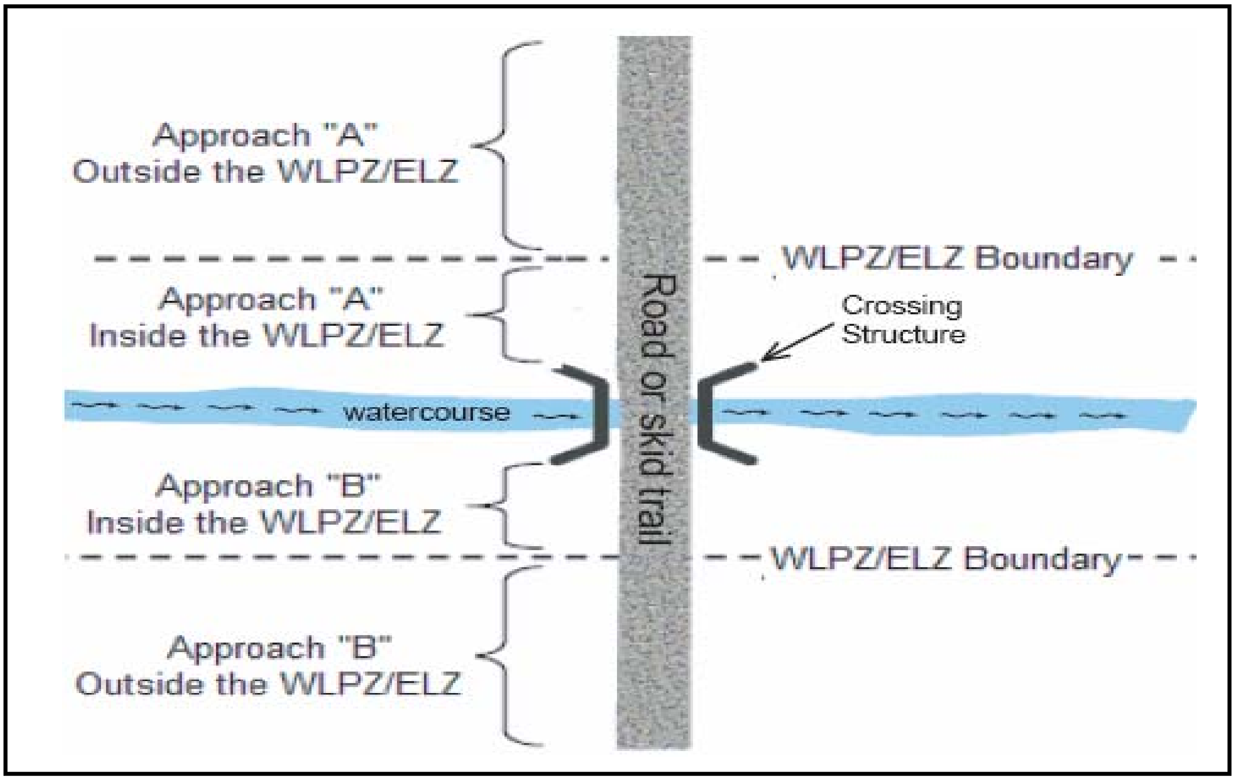

Figure 6. Typical protocol survey area, including approach areas A and B inside and outside the WLPZ/ELZ, and the crossing structure (Figure 2 in the IMMP Protocol Field Guide).

Field Testing

Field work began in July 2006 and was divided into two data collection phases (one in 2006 and the other in 2007), with each phase followed by revisions to the monitoring protocol (see discussion above, "Adaption and Modification of USFS BMP Monitoring

Protocol”). Landowner cooperation was recognized as a key component to success of the pilot project. As such, a letter that described the pilot project with assurance that the project would not include legal/enforcement actions was widely distributed (e.g., sent to CFA, FLOC, CLFA, the Forest Guild, UC Cooperative Extension, Farm Bureau, Forest Stewardship newsletter).

a) Training

Two training sessions were conducted with the purpose of familiarizing field crews with the USFS BMP monitoring protocol questions, California specific questions, and data collection. Field training sites were located at Jackson Demonstration State Forest and nearby industrial timberlands in the northern part of Coast Range and at LaTour Demonstration State Forest in the Cascade Range during May and June of 2006 (Figures 7 and 8). Data was recorded on hand held computers (PDAs), as specified by the USFS BMP monitoring protocol. Each watercourse crossing and both road approaches to the crossing were photo documented with standardized protocols.

Figure 7. Pilot project training in western Mendocino County in May 2006.

Figure 8. Pilot project training on LaTour Demonstration State Forest, located in Shasta County, in June 2006.

b) Protocol Testing

Following training, the field crews evaluated watercourse crossings in their respective areas. Sites were located on both large and small private timberland ownerships. Of the 22 plans visited, all were THPs except for two Nonindustrial Timber Management Plans (NTMPs). Two THPs were associated with timberland conversions. A total of 54 crossings were evaluated by the two teams during 2006 and 2007. Generally, three to four crossings were evaluated per field day with each evaluation taking between 45 minutes and two hours to complete, depending on field team familiarity with protocol questions and crossing complexity. The Inland team inspected 14 additional crossings without using the protocol. An overall summary of the crossings evaluated during the pilot program is provided in Table 1.

Table 1. Summary of pilot project field testing of monitoring protocols.

	Coast Team	Inland Team	Totals
Crossings Inspected with Protocols	29	25	54
Crossings Inspected without Protocols[9]	0	14	14
Crossings Re-Inspected with Protocols	0	3	3
Total Crossings Evaluated	29	42	71
Total Number of Times Protocols Used	29	28	57
Plans	13	9	22
Field Days	9	14	23
Crossings/Day	3-4	3-4	3-4

Field sampling typically began by driving and/or walking to a pre-selected high risk watercourse crossing. After answering general questions, the portion of the "A" side road approach that was outside of the WLPZ/ELZ was identified using a cloth or nylon tape (Figure 9). Questions in the protocol about this portion of road approach were then answered. Next, road approach side "A" within the WLPZ/ELZ was observed and questions related to this segment were answered. The crossing structure itself was then evaluated, followed by an evaluation of road approach side "B" (inside and outside the WLPZ/ELZ). Finally, summary questions about total sediment delivery and overall performance of the crossing and approaches were answered. Late in the second field season, additional questions about water drafting sites within approach areas A and B were added to the protocol.

During the course of field work, problems in using the USFS BMP monitoring protocol were identified. In particular, the field teams found that the USFS protocol did not apply well to California forested watersheds, and included BMPs that are not relevant to California timber operations, while not addressing California FPR requirements. For example, the USFS protocol required making evaluations several hundred feet from the watercourse being evaluated, with observed sediment movement often being assessed in a watercourse other than the one being evaluated.

[9] After the Inland team completed protocol evaluations, additional crossings were inspected the same day without using the California watercourse crossing protocol due to the tedious nature of the process (i.e., "protocol fatigue") and because of limited field time.

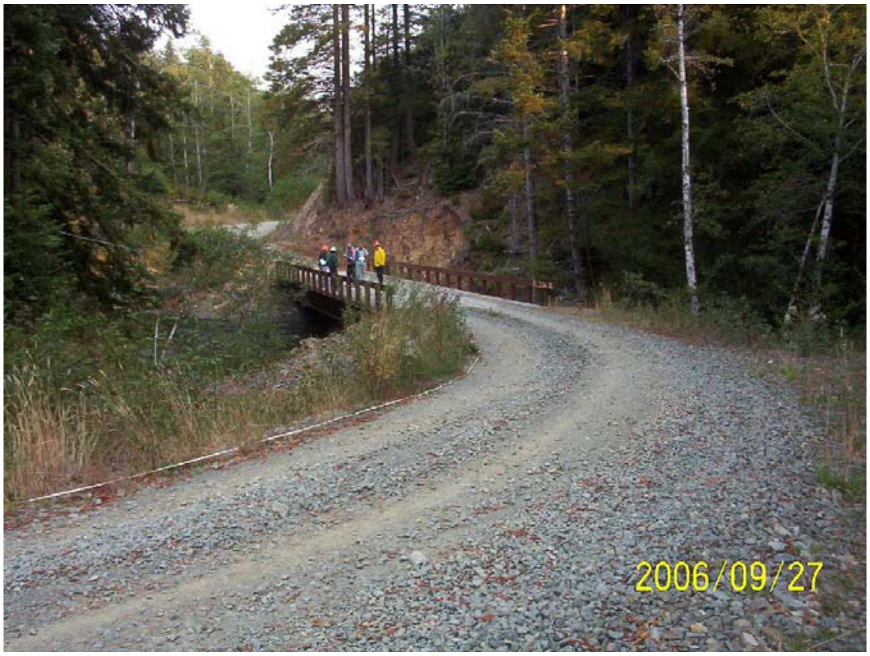

Figure 9. Bridge evaluated in Humboldt County by the Coast team during the 2006 field season. Note the tape stretched along the road approach to measure road length in the WLPZ.

c) Photo Documentation

Site conditions were documented with a series of digital photographs that were taken from the “A” side approach towards the crossing, the “B” side approach towards the crossing, upstream towards the crossing, and downstream towards the crossing. Additional photographs were taken of noteworthy features (e.g., where there was evidence of significant problems related to Forest Practice Rule implementation or effectiveness, such as fill slope failure, sediment deposition related to the crossing, etc.). A paper field photo log was developed to track photos (see example, Figure 10). While sketches were not regularly made during the pilot project, the photo log form includes space to draw sketches if needed. A blank photo log is included in the Protocol Field Guide (Appendix B).

IMMP PHOTOGRAPHIC REPORT

CAL FIRE · California Department of Fish and Game · Regional Water Quality Control Boards · California Geological Survey

Page	Of	Date	Protocol No. (enter code G1)	Plan No.	Crossing No.	Photographer:
1	1	7/18/2006	CA06N0004	2-05-060-SHA	4	Longstreth

Participants:	GPS Location Latitude N	GPS Location Longitude W	Crossing Type (enter code GC-110)
Cunningham, Wilson, Croteau, Longstreth	40.93096	122.49384	1 – Single Pipe Culvert

Overall Letter Grade For Crossing (enter code O-269)	Overall Letter Grade For Approaches (enter code O-270)
C	C

NARRATIVE DESCRIPTION OF PHOTOGRAPHS / SKETCHES

VIEW LOOKING UPSTREAM TOWARDS CROSSING OUTLET

Looking north, upstream (outlet), at the crossing. Note the boulders in the foreground. These boulders apparently originated from above the CMP where there is an evident lack of armoring. Also note the gully to the left of the armoring and the CMP. This apparently resulted when the crossing was overtopped this winter.

DISTANCE AND BEARING FROM CROSSING MIDPOINT (FEET):~ 25 feet/ North

PHOTO FILE NO. 3

VIEW LOOKING DOWNSTREAM TOWARDS CROSSING INLET

Looking south, downstream (inlet) of the crossing. Note the skewed installation of the CMP and the fresh excavation in the foreground. Forensic evidence indicated that this CMP overtopped and maintenance was conducted which resulted in the channel excavation pictured.

DISTANCE AND BEARING FROM CROSSING MIDPOINT (FEET):~ 40 feet/South

PHOTO FILE NO. 2

VIEW FROM APPROACH A SIDE

Approach A looking west towards crossing. Crossing is in the middle off the picture.

DISTANCE AND BEARING FROM CROSSING MIDPOINT (FEET):~ 50 feet/ West

PHOTO FILE NO. 1

VIEW FROM APPROACH B SIDE

Approach B looking east towards the crossing in the middle of the picture. Note gray road rocking in front of the pickup. This road material was found down slope in a gully indicating that the culvert likely overtopped.

DISTANCE AND BEARING FROM CROSSING MIDPOINT (FEET): ~40 feet/East

PHOTO FILE NO. 4

Figure 10. Example of a completed pilot project photo log.

Development of Protocol Field Guide

A field guide describing use of the protocol was developed at the beginning of the pilot project and substantially modified in 2007 (see Appendix B). The field guide includes a list of equipment needed to complete watercourse crossing evaluations, explanation of how to conduct field procedures, photo log and sketch procedures, monitoring tips, and definitions of terms used in the protocol. Also included are numerous illustrations and photographs to aid in the understanding of the protocol questions.

Data Recording

Fifty-four watercourse crossings were evaluated using protocols that varied from between 194 to 270 questions (depending on which revision of the protocol was being used). While not every question was answered during each evaluation, a substantial amount of data has been accumulated.[10] At the start of the 2006 field season, the field teams entered data directly into hand held PDAs (Figure 11), but it was determined that keeping track of the evaluation questions in the field was easier if paper forms were used. Some questions were inadvertently skipped when using the PDA because not all of the protocol questions are shown on the PDA screen at one time. Additionally, the PDAs were difficult to use in bright sunlight, and, in some instances, battery power was depleted before the end of the field session. As a result, much of the pilot program data was recorded on paper log sheets.

Figure 11. Anthony Lukacic, CAL FIRE, using a PDA for data entry during the LaTour Demonstration State Forest field training session in June 2006.

[10] For the seven watercourse crossing evaluations entered in the IMMP pilot project database, an average of approximately 120 questions per watercourse crossing were answered.

Database Development

A Microsoft Access database has been developed for entering and analyzing the pilot project data. Beta version 0.9 of this database has incorporated all the California watercourse crossing protocol questions and answers developed during the two-year pilot phase, and an intersect table has been developed to facilitate question branching and identifying unique answer codes. A responses table is provided to store the answers for each crossing. The database form includes several input masks, edit and new crossing prompts, sample queries, and at least one sample report. Examples of possible database queries, loosely tied to IMMP overarching questions, include the following:

- How many crossings (defined as the road area within bankfull channel width), where the provisions of both the FPRs and the plan were properly implemented, contributed measurable amounts of sediment to the watercourse?

- By what mechanism was the measurable amount of sediment delivered to the watercourse from the crossing (defined as the road area within bankfull channel width), where the FPRs and the plan were properly implemented?

- What was the one, primary cause or contributing factor of soil movement from the crossing (defined as the road area within bankfull), where the FPRs and the plan were implemented?

- What percentage of culvert crossings had diversion potential?

- What percentage of culvert crossings had a diameter equal to or larger than the active channel width?

- Number/percentage of crossings or approaches receiving various letter grades (i.e., A, B, C, D, and F).

- Percentages of crossings, by crossing type (e.g., culvert, ford, bridge, etc.) with different sediment delivery categories (e.g, trace (<1 cubic yard), 1-10 cubic yards, 11-50 cubic yards, etc.).

IMMP PILOT PROJECT FINDINGS

Field work completed in 2006 and 2007 by the two pilot project field teams provide the following products and conclusions. Because the pilot project protocols were revised several times during collection of field data, not all data is comparable, which limits formal analysis of the overall data set.

- **Development of a watercourse crossing evaluation protocol.**

  As described above, a portion of the existing USFS BMP monitoring protocol was used as the starting point for IMMP watercourse crossing evaluations. During the course of the pilot project, the field teams determined that the USFS protocol, while detailed, did not adequately account for situations routinely found on state and private land timber harvesting projects in California. The IMMP teams, with support from the IMMP Subcommittee, made and tested several protocol revisions to more accurately reflect conditions as found in California THPs. The resulting IMMP protocol can be used by Review Team agencies and the regulated public to evaluate how well practices associated with perceived "high risk" watercourse crossings are performing.

- **Demonstration that the Review Team agencies can work together cooperatively and achieve consensus, with a greater appreciation for each agency's concerns and objectives related to the impacts from timber harvesting (Figures 12 and 13).**

  All the Review Team agencies agree protection of resources at risk (e.g., soil, water quality, biological) are of primary importance. However, during the review process, agency representatives may disagree as to the best way to specify crossing mitigation within a plan, or even if a given mitigation is necessary. These differing opinions can affect the overall review process, both by creating tension among the Review Team members and occasionally by affecting individual landowners. Such inability to reach consensus can lead to longer plan review periods.

  The IMMP process allowed Review Team agency representatives to work together in a non-regulatory environment without review process concerns, regulatory timelines, and competing and sometimes conflicting regulations. This more "relaxed" situation allowed the members of the IMMP field teams to focus on evaluating the selected watercourse crossings, often prompted spirited discussion, and ultimately led to consensus on all watercourse crossings evaluated. This environment and discussion also led to a greater appreciation among the Review Team agencies for each agency's expertise and concerns that are not always obvious during the narrowly focused review process.

Figure 12. Pilot project Inland team members Dave Longstreth, CGS, and Joe Croteau, DFG, at a culvert installed on a THP in Shasta County in August 2006.

Figure 13. Pilot project Coast team members Dave Longstreth, CGS, and Richard Fitzgerald, DFG, evaluating a removed watercourse crossing in Mendocino County in August 2006.

- **Agreement that the IMMP approach to interagency problem solving should be fostered and continued, but not limited to watercourse crossings.**

  A goal of the IMMP was to encourage Review Team agencies to work cooperatively and reach consensus on issues related to timber harvesting. As noted previously, high risk watercourse crossings were selected as the subject of the pilot project to test this approach. However, it was not the intent of the IMMP Subcommittee to focus exclusively on watercourse crossings for the long-term program. Rather, it was agreed that the IMMP process should be used to look at multiple issues related to the impacts of timber harvesting on resources at risk.

- **For the IMMP team members, the pilot project was a beneficial training exercise for evaluating watercourse crossings and an effective team building exercise.**

  The detailed evaluation of watercourse crossings required by the protocol developed a heightened appreciation in IMMP Team members for what is required to properly install or remove a watercourse crossing. This awareness has carried over to team members' duties on Pre-Harvest Inspections (PHIs), routine plan inspections, etc.

  The detailed evaluation of watercourse crossings required by the protocol increased the awareness of the IMMP teams to the issues surrounding watercourse installation (including upgrading) and removal. It also pointed to the need for follow-up inspections by trained staff to insure proper implementation of required practices. Finally, the protocol helped the team members recognize the need to evaluate the entire crossing area, including road approaches and the watercourse upstream and downstream of the crossing.

- **Virtually all watercourse crossings or approaches to crossings deliver some sediment, even when the Forest Practice Rules or any additional THP specific mitigation measures are followed appropriately.**

  The detailed evaluation of watercourse crossings required by the protocol revealed that virtually all crossings and/or the associated approaches delivered some sediment to a watercourse. This sediment delivery consisted of "trace" (defined as less than one cubic yard) amounts for the majority of evaluated crossings. But some sediment was delivered. The IMMP teams concluded that, while it appears some sediment delivery is unavoidable, assiduously following the Forest Practice Rules and THP requirements generally limited delivery to trace amounts. There was general agreement that: (1) it is nearly impossible to stop trace amounts of fine sediment from entering watercourses at crossings, (2) better location and installation of road drainage facilities/structures is required near crossings to prevent larger amounts of sediment from being delivered, (3) rock, mulch, or additional sediment control measures are often needed on road approaches near crossings to limit sediment entry, and (4) training and oversight of crossing installation is necessary.

- **Improper installation of crossings and drainage structures near crossings, and improper crossing removal, are major causes of sediment movement and deposition, which is consistent with findings of both the earlier HMP and MCR studies.**

  Installation problems included misapplication of the requirements of the Forest Practice Rules/BMPs or THP-specific engineering requirements, or simply poor workmanship.

- **The high value of photo logs to document practices.**

  The final IMMP protocol specifies that at least four photos be taken of every crossing (upstream and downstream of each crossing and from both approaches). The resulting photo logs provide a means of comparison for crossings that are re-inspected, allowing the Review Team agencies and the regulated public to evaluate how well crossings have held up over multiple winters. The photo log catalogs well installed and poorly installed crossings that can be used for training purposes.

- **Although the protocol was comprehensive, repetitious, and tedious to use, it forced team members to be objective and was instrumental in allowing the team members to reach consensus.**

  The pilot project protocol is tedious to carry out. As a result, the IMMP teams often reached the point of “protocol fatigue” by the end of the day. This condition increased as the field portion of the pilot protocol progressed. However, the required attention to detail forced the team members to work in a more cooperative manner than is generally experienced during PHIs and Review Team meetings, which often require agency representatives to focus on individual resources. This positive atmosphere led to greater appreciation for each agency’s expertise and concerns, provided an effective team building exercise, and was also instrumental in reaching team consensus.

- **Although more time was often spent on road approaches than on the crossing itself, this effort revealed that a high percentage of problems (i.e., sediment transport and deposition into a watercourse) originate on the approaches.**

  The Forest Practice Rules and THP specific mitigations, as well as evaluations during PHIs, generally focus on the relatively small area taken up by the crossing because the relatively large amount of earth movement during installation is considered to be the major potential source of sediment to the watercourse.

  However, when tracking potential sediment sources from origin to the final deposition point, as required by the protocol, the field teams discovered that sediment deposited in the WLPZ or within bankfull stage often originated from the approaches, or was in addition to sediment being input from crossing installation or removal.

- **In areas not dominated by mass wasting processes, the majority of management-related sediment input into watercourses is often a result of poor installation or maintenance of crossings and associated road approaches. This includes installation and maintenance of road drainage structures and appropriate road surfacing near crossings.**

  Reducing sediment deposition into a watercourse can be accomplished with improved installation, maintenance, and removal practices at and near crossings. IMMP field team members have concluded that this requires:

  1. Improved Licensed Timber Operator (LTO) training. LTO recognition of the importance and need for quality installations is a key factor in reducing sediment input. This training should include why sediment input into a watercourse can result in an adverse impact to the beneficial uses of water.

  2. Greater emphasis placed on active and post-active multi-agency inspections. Inspections by trained staff from all Review Team agencies will allow potential problems to be noted and addressed. This could also reduce adverse effects from poor implementation or maintenance-related issues.

IMMP PILOT PROJECT DISCUSSION AND LIMITATIONS

The pilot project has accomplished a majority of its goals. A monitoring protocol that promotes interagency interaction and cooperation and that addresses overarching agency questions about watercourse crossing design and installation has been developed, tested, and is ready for routine use. In addition, a database application has been developed to automate data entry and analysis.

Interagency Interaction and Cooperation

The California watercourse crossing protocol is a labor intensive process, where the same or very similar questions are asked several times during an evaluation. This repetition may appear to be a limitation, but field testing found the process to focus attention on details that may be overlooked under other circumstances. The protocol also promoted field discussions at crossing evaluation sites and required development of answers to subjective summary questions. This led to consensus among different agency representatives about the extent and cause of observed problems and how crossing installation or design might be improved.

Field team interactions improved the quality of observations and analysis skills of individual team members for evaluating watercourse crossing performance and potential for sediment delivery. Both field teams found that the pilot project promoted interagency cooperation, consensus building, and development of interpersonal communication skills. The teams also determined that use of the California watercourse crossing protocol could provide useful training for both the government and private sectors.

Development of Database, Analysis, and Overarching Questions

A Microsoft Access database was developed for data entry and to analyze pilot project data. Field data from seven watercourse crossing evaluations that utilized the most recent version of the protocol have been entered into the database. From this limited sample, it appears that queries can be developed to answer agency overarching questions. However, because the monitoring protocol includes dependent layers, these queries may capture only a portion of the monitoring protocol data related to an overarching question. Moreover, because overarching questions encompass numerous generalized issues while the monitoring protocol asks very specific questions, it may take several queries to address one overarching question.

Because sampling was limited to “high risk” crossings, a non-random method of site selection was used. As a result, the pilot project was not a “scientific” or “statistically valid” study. Results from this approach may be useful in understanding impacts from high risk watercourse crossings in California, but does not provide a basis for developing generalized principles or conclusions.

Field Monitoring, Corrective Actions, and Water Quality Protection

The pilot project focused on the effectiveness of current practices, and not on legal/enforcement actions. Field observations did, however, lead to implementation of some corrective work to reduce the potential for sediment delivery before stressing winter storms. Such corrective work required communication with the RPF and LTO responsible for the THPs. Additionally, it became clear to the field teams that forest practices could be corrected and improved upon utilizing increased multi-agency inspection that results in LTO and RPF education.

Timber Harvest Review Efficiency

The California watercourse crossing protocol produced by the IMMP pilot program encourages interagency cooperation, normalization of observation skills, and development of multi-agency post PHI (active and post active) inspections to minimize the potential for sediment delivery. This is consistent with the recommendations of larger statewide plans that call for improvements in timber harvesting review efficiency that conserve available financial, governmental, physical, and social resources, while providing more expeditious review timelines.

Comparability to Other Monitoring Programs

Because the California watercourse crossing protocol was adapted from the USFS BMP monitoring protocol (Welsch and others 2007), many of the questions remain the same or are very similar. As such, comparison of IMMP protocol findings with results from states using the USFS BMP monitoring protocol may be possible. Such analyses, however, have not been completed to date.

While the pilot project may be used to evaluate the implementation and effectiveness of practices at high risk, non-random watercourse crossings in California, it cannot answer all relevant water quality-related monitoring questions. To put the results of the IMMP work into proper context, it must be viewed as only one part of several additional monitoring projects already being undertaken in California (Figure 14). These efforts include monitoring work that occurs on all or a large percentage of plans (e.g., Forest Practice inspections conducted by CAL FIRE, DFG 1600 permit inspections), a random 10 percent selection of plans for crossing, road, and WLPZ monitoring known as FORPRIEM (Forest Practice Rule Implementation and Effectiveness Monitoring) conducted by CAL FIRE, and a limited number of instream watershed-scale research projects/instream channel monitoring studies (e.g., Caspar Creek, Kings River Experimental Watershed [KREW] study, South Fork Wages Creek, Judd Creek, etc.).

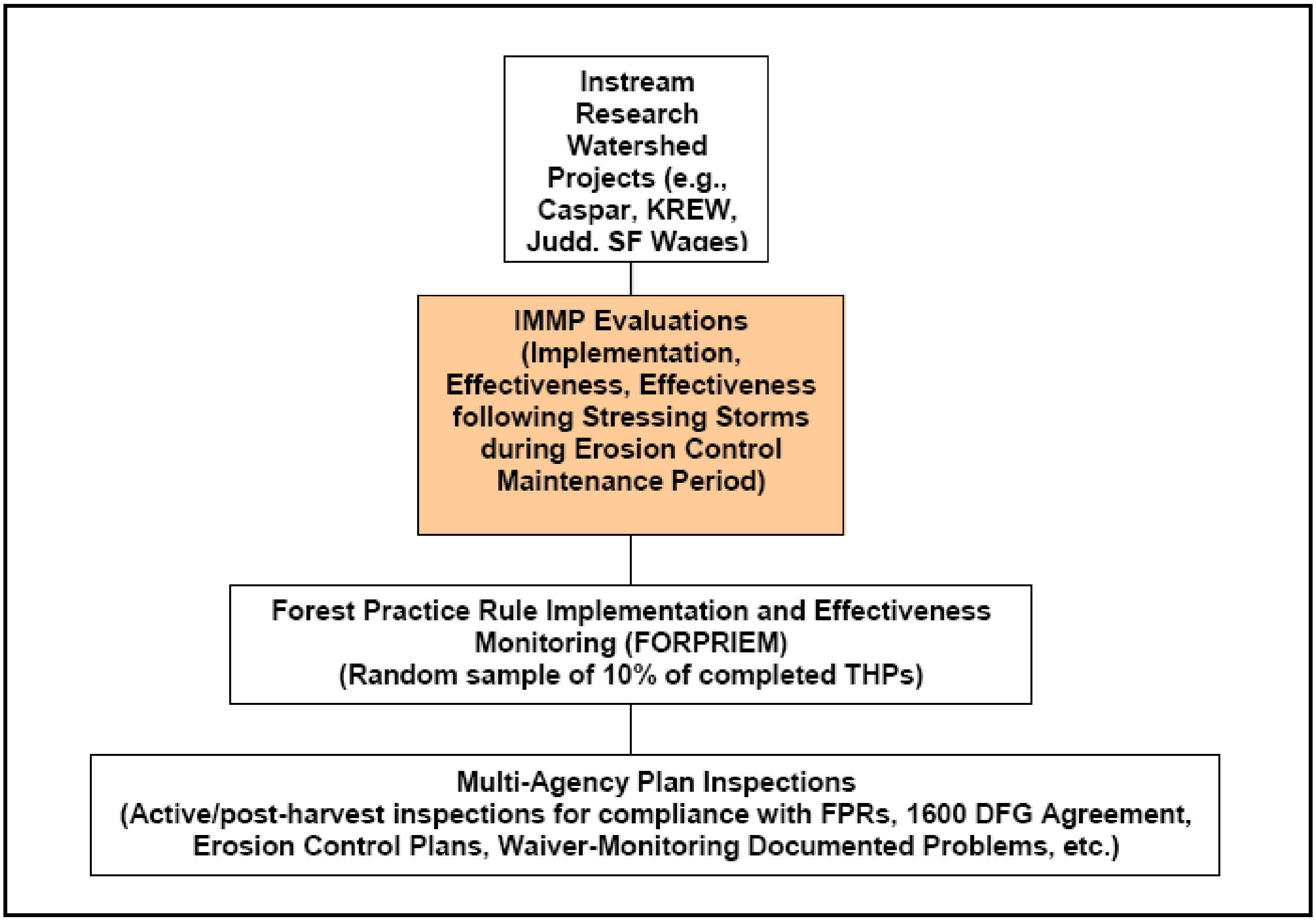

Figure 14. Diagram illustrating the relationship of IMMP work to other water quality-related monitoring approaches currently underway in California.

Wider Concerns Regarding Timber Harvest Practices in California

The IMMP pilot project is focused on evaluation of high risk watercourse crossings and the road approaches to the crossings. It does not address a variety of other topics and issues regarding review of timber harvesting in California (e.g., tree removal (harvesting, wildfire) versus impacts to habitat, slope stability, water quality and public safety). While the IMMP pilot project has been successful in meeting its initial goals regarding interagency study of high risk watercourse crossings, future work by the IMMP Subcommittee will need to be implemented to address these other issues.

IMMP PILOT PROJECT RECOMMENDATIONS

The recommendations developed from the pilot project are as follows:

1. Use the current version of the protocol as a multi-agency **training tool** to help field personnel recognize critical situations on post-harvest Erosion Control Maintenance Program (ECMP) inspections. There is consensus that the IMMP watercourse crossing protocol should be used as a **mandatory** Review Team training tool, allowing agency staff to benefit and learn from the IMMP "process."

2. Form interagency teams of professionals and/or technicians from the Review Team agencies to fully implement the IMMP watercourse crossing protocol. Agency personnel from all the Review Team agencies should be trained on erosional processes at and near crossings, rotating agency staff into multiple regional teams on a regular basis to prevent staff "burn-out." Resource professionals and/or technicians can do this work if: (1) they are adequately trained, (2) they carefully read and consider the questions, (3) they have observational skills, (4) they have a basic understanding of erosion processes and BMPs, and (5) the IMMP Subcommittee has an adequate quality assurance/quality control (QA/QC) program in place to check their work.

3. Create QA/QC field team(s) from experienced personnel to provide oversight of the rotating IMMP field teams. The IMMP Subcommittee should develop QA/QC procedures that will utilize CAL FIRE Monitoring Foresters and other agency representatives as available, to verify data accuracy and consistent application of the IMMP protocols.

4. Create a dedicated database site where interagency teams may deposit data and photographic logs. The database site will require dedicated personnel capable of managing and processing data, conducting data analysis, and reporting results on a regular basis to the regulated public, agency managers, and appropriate boards.

5. Continue interagency outreach to landowners, RPFs, LTOs, and agency representatives based on the results of monitoring work. Training should also be provided to RPFs and landowners on use of the IMMP watercourse crossing protocol on their lands, with the goal of improving crossing practice implementation and ensuring effective crossing design in THP development.

6. The State Board of Forestry and Fire Protection's newly forming Research and Science Committee should investigate the use of the IMMP watercourse crossing protocol to meet various agency monitoring requirements, including monitoring requirements in watersheds with state and federally listed coho salmon.

7. Provide adequate funding and agency personnel years for full implementation of the IMMP watercourse crossing protocol, to support training programs, and to develop and test monitoring protocols developed by the IMMP Subcommittee for timber

operations. Funding should be sought through a joint agency Budget Change Proposal. The Board and the IMMP Subcommittee members should also investigate the possibility of acquiring funding from other sources, including state, federal and/or private grants to support this work.

8. Evaluate the remainder of the U.S. Forest Service's "Repeatable Regional Protocol for Performance-Based Monitoring of Forestry Best Management Practices" (Welsch and others 2007) utilizing the IMMP Subcommittee, to determine if more comprehensive and efficient protocols could be developed for additional practices used to protect water quality in California.

9. Use the IMMP field teams to refine and test new monitoring protocols determined to be appropriate by the IMMP Subcommittee.

10. Utilize the IMMP Subcommittee and IMMP field teams to: (1) examine other issues of concern related to timber harvesting operations; (2) facilitate the resolution of issues in a mutually agreeable manner; (3) develop recommendations for each team member's respective agency's management, and (4) develop curriculum for interagency training. This will continue improvements in agency response to timber harvesting issues to protect water quality and increase efficient THP review.

ACKNOWLEDGEMENTS

We thank all the landowners that assisted us with the pilot project during 2006 and 2007. Large landowners included: Collins Pine Company, Crane Mills, Green Diamond Resource Company, Hawthorne Timber Company/Campbell Timberland Management, Mendocino Redwood Company, The Pacific Lumber Company, Redwood Empire, Roseburg Resource Company, and Sierra Pacific Industries. Company personnel were very cooperative and several representatives attended IMMP field inspections. Small landowners included: Peter Michael Winery, Nash Creek Vineyards Inc., Bohemia Ranch, LLC, Diane Marvin, Greg Gates, and George Koenig. We also acknowledge the staff on Jackson and LaTour Demonstration State Forests for their assistance with the pilot project field training sessions in the spring of 2006. Mr. Dave Welsch, U.S. Forest Service Northeastern Area State and Private Forestry, and Dr. Robert Sacks, Blue Jay Software Associates, provided generous assistance with the USFS BMP Monitoring Protocols and the software program used with the pocket computers in 2006. Mr. Doug Burch, California Department of Fish and Game, developed the majority of the pilot project database.

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APPENDICES

APPENDIX A—CALIFORNIA WATERCOURSE CROSSING PROTOCOL

G-1 Enter the code for the state, year, sample type, iteration, and sample crossing number.

> Examples: California, 2006, new sample, initial measurement, crossing number 24 would be coded CA 06 N 0 024.
>
> If this same crossing was re-sampled for quality control purposes it would code CA 06 Q 0 024
>
> If this same crossing was re-sampled the first time, the following year, it would code CA 07 R 1 024

G-2 Enter the code for the plan number (x-yy-zzz AAA), where x = Forest Practice District number, yy = year plan was filed, zzz = plan number, and AAA = county abbreviation.

G-3 Enter the number of whole acres in the harvest area as stated in the plan.

G-4 Enter the crossing identification number provided in the plan.

G-5 Enter the code indicating if the crossing was a pre-identified high risk crossing.

1. Yes
2. No

G-6 Enter the code indicating landowner category

1. Non-industrial private forest landowner
2. Industrial forest landowner
3. Public forest landowner
4. Other – Land trust etc
5. Unknown
6. Harvest area is being / has been developed for non forest use.

G-7 Enter the code that best describes the primary adjacent land use for the crossing.

1. Forest
2. Agriculture
3. Residential/Commercial
4. Other

G-8 Is there a DFG 1600 agreement.

1. Yes
2. No
3. Unknown

G-9 Enter one or more codes that describe the plan requirements for the crossing site being evaluated.

1. Standard California Forest Practice Rules including the Threatened and Impaired Watersheds Rule Package (July 1, 2000) where appropriate.
2. Additional mitigation measures assigned during plan review were required and/or the RPF proposed additional measures, which were above and beyond the FPRs.
3. Exceptions, alternatives or in-lieu practices were proposed, which superseded the standard Forest Practice Rules.

Note: The response to this question modifies and pertains directly to the questions regarding Principles and Practices.

G-10 Is there evidence that the crossing site is actively being used?

1. Yes. (Go to G11)
2. No. (Go to G12)

G-11 Is the use identified in G-10 associated with active timber operations?

1. Yes.
2. No.

G-12 Enter the code for the Erosion Hazard Rating (EHR) listed in the plan for the crossing area.

1. Low
2. Moderate
3. High
4. Extreme

G-13 Enter the code indicating the specific underlying rock type/formation. The standard geologic formation letter symbology is recorded (e.g., Mesozoic granitic rocks = g r).

G-14 Enter the code indicating the predominant type of landslide under the crossing or approaches. See Appendix B and C for diagrams and descriptions of each geologic feature.

1. No observed landslide
2. Active rockslide
3. Dormant rockslide (translational/rotational)
4. Active debris flow or debris slide
5. Dormant debris flow or debris slide
6. Active earthflow
7. Dormant earthflow
8. Inner gorge
9. Debris slide slope

G-15 Enter the code for the watercourse class of the channel being evaluated at the crossing site.

1. Class I
2. Class II
3. Class III
4. Class IV

G-16 Enter the code indicating the water body type being crossed.

1. Perennial.
2. Intermittent.
3. Ephemeral.

G-17 Enter the GPS latitude of the water crossing being evaluated based on NAD 83. Enter as decimal degrees latitude including the decimal point and six decimal places.

G-18 Enter the GPS longitude of the water crossing being evaluated based on NAD 83. Enter as decimal degrees longitude including the decimal point and six decimal places.

G-19 Enter the code indicating whether you are evaluating a haul road or skid .

1. Haul road
2. Skid trail

G-20 Has the crossing "over wintered" at least one winter period?

1. Yes, go to G-21.
2. No, go to O-265

G-21 Did the crossing experience a rare or extreme weather event likely to have influenced the crossing during the last winter period?

1. Yes.
2. No.
3. Unknown

Examples may include rain on snow events, severe rainstorms, severe drought, etc,

WATER BODY CROSSING APPROACH AREA A

AG-22 Enter the WLPZ/ELZ width in whole feet based on the plan or Forest Practice Rules for approach A of the water body being crossed.

AG-23 Enter the code that describes the current road/skid trail status.

1. New
2. Existing
3. Reconstructed
4. Abandoned

AG-24 Enter the code indicating the road type.

1. Permanent road
2. Seasonal road
3. Temporary road
4. Skid Trail

Approach Area A-Outside the WLPZ/ELZ

Establish the protocol survey area on Approach Area A by measuring the distance on the road surface equivalent to 3X the WLPZ/ELZ width or 300 feet, whichever is less. Distances are measured from bank full.

If within this distance, there are topographic features or a change in grade that prohibits road drainage from draining to the subject watercourse, the upland boundary of the protocol survey area is established at that point. This change is not applicable for drainage facilities including waterbreaks or rolling dips and the change must be continuous throughout the remainder of the measured distance.

AO-25 Does Approach Area A exit the WLPZ/ELZ within this distance?

1. If yes, go to AO26.
2. If no, go to AI53

Approach Area A-Outside the WLPZ/ELZ DEFINED

Approach Area A-Outside the WLPZ/ELZ originates at the upland edge of the WLPZ/ELZ and extends inland perpendicular to the bank to the edge of the protocol survey area. When road runoff drains away from the watercourse crossing, the protocol survey area is truncated at that point and further survey beyond that point is not necessary. For this purpose, ignore road drainage facilities such as waterbreaks or rolling dips.

If there is no WLPZ/ELZ, limit the approach area outside the WLPZ/ELZ to 25 feet.

Observe the conditions on the ground within Approach Area A - Outside the WLPZ/ELZ and answer the questions. You may have to follow some indicators such as rills, ruts or gullies into the approach area inside the buffer or into the water body itself to answer the questions.

AO-26 Enter the code that best describes the road prism inApproach Area A – Outside the WLPZ/ELZ

1. Landing adjoining maintained road.
2. Road/trail insloped with no inside ditch.
3. Road/trail insloped with an inside ditch.
4. Road/trail outsloped with no inside ditch.
5. Road/trail outsloped with an inside ditch
6. Road/trail crowned with an inside ditch.
7. Road/trail crowned with no inside ditch
8. Road/trail inverted below general grade of adjoining land (includes through cuts and roads on flat ground).
9. Road/trail bermed with no inside ditch.
10. Road/trail bermed with an inside ditch.

AO-27 Enter the code that best describes the road construction at Approach Area A – Outside the WLPZ/ELZ.

1. Road/trail profile created by cut and fill construction.
2. Road/trail profile created by full bench construction.
3. Road/trail profile created by through fill.
4. Road/trail created by through cut.
5. Road/trail created with no cut or fills (i.e. road on flat ground)

AO-28 Is the drainage from the road surface of Approach Area A – Outside the WLPZ/ELZ diverted off the road prism by a drainage facility before it reaches the crossing?

1. Yes
2. No
3. Not applicable, crossing is higher in elevation than Approach Area A.

AO-29 Enter the code that best describes predominant improvements used on any portion of the road / trail in Approach Area A-Outside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as Geo-textile, pallets, mats, slash, corduroy etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

AO-30 Enter the percent grade of the road / trail in Approach Area A- WLPZ/ELZ measuring from the upland edge of the WLPZ/ELZ at the crossing.

Enter + for a positive or upgradient and - for a negative or downgradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

AO-31 Enter the code that best describes any soil movement on Approach Area A-Outside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bankfull width of the channel. (go to question AO-32)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bankfull width of the channel. (go to question AO-32)
3. Soil was deposited inside the WLPZ/ELZ, but did not reach the water body or within the bankfull width of the channel. (go to question AO-41)
4. Soil moved in Approach Area A-Outside the WLPZ/ELZ, but did not reach the WLPZ/ELZ. (go to question AI-49)
5. Soil is stabilized for Approach Area A-Outside the WLPZ/ELZ (go to question AO-48)

In cases where the sediment delivery system (AO-32) indicates strongly that measurable volumes of sediment have been deposited in the water body, but have since been washed away, enter “1” for question AO-31 and enter “0” for question AO-35.

Locate the boundaries of the area in question and carefully inspect the road or trail as well as any ditches and adjoining cut or fill slopes. Look for evidence of soil movement such as rills, gullies or other sediment trails. Consider also material moved by machines during construction as well as material pushed by wheels or dragged by logs.

Depending on the time of year it may be necessary to brush away newly fallen leaves to follow the sediment trail. Sediment occurring above or below the various leaf layers will provide clues as to whether the erosion occurred during a prior harvest or is ongoing.

Only one code can be entered. Consider the various problems evident and report on the worst case scenario choosing the answer codes that best describe the situation.

Sediment deposited in the water body from Approach Area-A, Outside the WLPZ/ELZ

AO-32 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from Approach Area A-Outside the WLPZ/ELZ.

1. Ditch or rut (wheel, track, log drag, etc). (go to question AO-33)
2. Gully. (go to question AO-33)
3. Rill (go to question AO-35)
4. Sheet flow, sediment deposition trail or alluvial fan. (go to question AO-35)
5. Soil slumping or dropping. (go to question AO-35)
6. Mechanical deposition. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question AO-35)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form continuously evolves into another (such as when a rill becomes a gully) record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut etc.

AO-33 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question AO-32.

Where one erosion form continuously evolves into another (such as when a rill becomes a gully) measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

AO-34 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question AO-32.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

AO-35 Enter the currently evident volume of sediment deposited in the water body or within the bankfull width of the channel in whole cubic yards by the delivery system identified in question AO-32.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole yards.

Enter “0” if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

AO-36 Enter the code that best describes the predominant type of sediment delivered to the water body or to within the bankfull width of the channel by the delivery system identified in question AO-32.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AO-37 Can sedimentation be expected to occur during the next storm event based on your answers to questions AO-32 through AO-36.

1. Yes.
2. No.
3. Unknown.

AO-38 Were principles / practices applied?

1. Yes.
2. No.

AO-39 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AO-40 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from Approach Area A-Outside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering proceed directly to question AI-49

Sediment deposited inside the WLPZ/ELZ, but not the water body from Approach Area A-Outside the WLPZ/ELZ

AO-41 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

AO-42 Enter the code that best describes the evidence that sediment reached the WLPZ/ELZ but not the water body nor to within the bankfull width of the channel from Approach Area A-Outside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion feature continuously evolves into another (such as when a rill becomes a gully) record the dominant form.

AO-43 Enter the code that best describes the predominant type of sediment delivered to the WLPZ/ELZ, but not the water body nor to within the bankfull width of the channel, by the delivery system identified in question AO-42.

1 Organic material
2 Clay (forms ribbon 1 inch or longer)
3 Silt / loam (feels smooth but will not form ribbon)
4 Sandy (feels gritty)
5 Gravel (0.8 – 2.5 inches)
6 Cobble & larger (> 2.5 inches)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AO-44 Can sedimentation be expected to occur during the next storm event based on your answers to questions AO-42 and AO-43.

1. Yes.
2. No.
3. Unknown.

AO-45 Were principles / practices applied?

1. Yes.
2. No.

AO-46 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AO-47 Enter the code that best describes the specific cause of sediment delivery to the WLPZ/ELZ (but not the water body nor to within the bankfull width of the channel) from Approach Area A-Outside the WLPZ/ELZ.

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering proceed directly to question AI-49

<u>Soil stabilized in Approach Area-A, Outside the WLPZ/ELZ</u>

AO-48 Were principles / practices applied?

1. Yes.
2. No.

After answering question AO-48 and reading the following explanation proceed directly to question AI-49.

Approach Area-A, Inside the WLPZ/ELZ

Approach Area A-Inside the WLPZ/ELZ originates at the outer edge of the stream's bankfull width and extends to the outer edge of the WLPZ/ELZ.

Observe the conditions on the ground within Approach Area A-Inside the WLPZ/ELZ and answer the questions.

Report only those conditions that originate from the approach area inside the buffer. Conditions originating beyond the approach area inside the buffer were reported in the previous section.

AI-49 Is there a WLPZ/ELZ?

1. Yes, go to AI-50
2. No, go to GC-101

AI-50 Enter the percent grade of the road / trail in Approach Area A Inside WLPZ/ELZ measuring from the bankful width of the water body at the crossing.

Enter + for a positive or uphill gradient and - for a negative or down hill gradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

AI-51 Enter the code that best describes improvements used on any portion of the road / trail in Approach Area A-Inside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as geo-textile, pallets, mats, slash, corduroy etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

AI-52 Enter the code that best describes the road prism Approach Area A – Inside the WLPZ/ELZ

1. Landing adjoining maintained road.
2. Road insloped with no inside ditch.
3. Road insloped with an inside ditch.
4. Road outsloped with no inside ditch.
5. Road outsloped with an inside ditch
6. Road crowned with an inside ditch.
7. Road crowned with no inside ditch
8. Road inverted below general grade of adjoining land (includes through cuts and roads on flat ground).
9. Road bermed with no inside ditch
10. Road bermed with inside ditch.

AI-53 Enter the code that best describes the road construction Approach Area A – Inside the WLPZ/ELZ

1. Road/trail profile created by cut and fill construction.
2. Road/trail profile created by full bench construction.
3. Road/trail profile created by through fill.
4. Road/trail created by through cut.
5. Road/trail created with no cut or fills (i.e. flat ground)

AI-54 Is the drainage from the road surface Approach Area A – Inside the WLPZ/ELZ diverted off the road prism by a drainage facility before it reaches the crossing?

1. Yes
2. No
3. Not applicable, crossing is higher in elevation than Approach Area A.

AI-55 Enter the code that best describes any soil movement on Approach Area A-Inside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bankfull width of the channel. (go to question AI-56)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bankfull width of the channel. (go to question AI-56)
3. Soil moved in Approach Area-A, Inside the WLPZ/ELZ, but did not reach the water body nor to within the bankfull width of the channel. (go to question AI-65)
4. Soil is stabilized for Approach Area-A, Inside the WLPZ/ELZ (go to question AI-72)
5. Soil movement occurs in Approach Area-A, Inside the WLPZ/ELZ, but has been recorded elsewhere in the protocol. (go to question AI-74)

In cases where the sediment delivery system (AI-56) indicates strongly that measurable volumes of sediment have been deposited in the water body, but have since been washed away, enter "1" for question AI-55 and enter "0" for question AI-59.

Locate the boundaries of the area in question and carefully inspect the road or trail as well as the ditches and adjoining cut or fill slopes. Look for evidence of soil movement such as rills, gullies or other sediment trails. Consider also material moved by machines during construction as well as material pushed by wheels or dragged by logs.

Depending on the time of year it may be necessary to brush away newly fallen leaves to follow the sediment trail. Sediment occurring above or below the various leaf layers will provide clues as to whether the erosion occurred during a prior harvest or is ongoing.

Only one code can be entered. Consider the various problems evident and report on the worst case scenario choosing the answer codes that best describe the situation.

Sediment deposited in the water body from Approach Area A Inside the WLPZ/ELZ

AI-56 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from Approach Area A-Inside the WLPZ/ELZ.

1. Ditch or rut (wheel, track, log drag, etc). (go to question AI-57)
2. Gully (go to question AI-57)
3. Rill (go to question AI-57)
4. Sheet flow, sediment deposition trail or alluvial fan (go to question AI-59)
5. Soil slumping or dropping (go to question AI-59)
6. Mechanical deposition of soil. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question AI-59)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form evolves into another in a continuous manner such as when a rill becomes a gully, record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut, etc.

AI-57 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question AI60.

Where one erosion form evolves into another in a continuous manner, such as when a rill becomes a gully, measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

AI-58 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question AI-56.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

AI-59 Enter the currently evident volume of sediment deposited in the water body or to within the bankfull width of the channel in whole cubic yards by the delivery system identified in question AI-56.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole cubic yards.

Enter "0" if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

AI-60 Enter the code that best describes the predominant type of sediment delivered to the water body or to within the bankfull width of the channel by the delivery system identified in question AI-56.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 inches)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AI-61 Can sedimentation be expected to occur during the next storm event based on your answers to questions AI-56 through AI-60.

1. Yes.
2. No.
3. Unknown.

AI-62 Were principles / practices applied?

1. Yes.
2. No.

AI-63 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AI-64 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from Approach Area A-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question AI-73

Soil moved in Approach Area A-WLPZ/ELZ, but did not reach the water body

AI-65 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

AI-66 Enter the code that best describes the evidence that soil moved, but did not reach the water body nor to within the bankfull width of the channel from within Approach Area A-Inside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion form continuously evolves into another(such as when a rill becomes a gully) record the predominant form.

AI-67 Enter the code that best describes the predominant type of soil that was moved, but did not reach the water body nor to within the bankfull width of the channel by the delivery system identified in question AI-66.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AI-68 Can sedimentation be expected to occur during the next storm event based on your answers to questions AI-66 and AI-67.

1. Yes.
2. No.
3. Unknown.

AI-69 Were principles / practices applied?

1. Yes.
2. No.

AI-70 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AI-71 Enter the code that best describes the specific cause of soil movement in Approach Area A-Inside the WLPZ/ELZ.

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question AI-73

Soil stabilized In Approach Area A-Inside the WLPZ/ELZ

AI-72 Were principles / practices applied?

1. Yes.
2. No.

After answering question AI-72 proceed directly to question AI-73

AI-73 Enter the code that best describes the preponderant hydrologic soil type in Approach Area A- Inside the WLPZ/ELZ.

1. Type A (sand/gravel - feels gritty)
2. Type B/C (loams – feels crumbly)
3. Type D (silt, clay, muck – smooth, plastic to gelatinous)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

Water Drafting - Approach Area-A, Inside the WLPZ/ELZ

AID-74 Is there a water drafting approach constructed in Approach Area A – Inside the WLPZ/ELZ

1. Yes. (If yes, go to AID-75)
2. No. (If no, go to CG76)

AID-75 Enter the length, in feet, of the water drafting approach constructed in Approach Area A – Inside the WLPZ/ELZ

AID-76 Enter the percent grade of the water drafting approach in Approach Area A Inside the WLPZ/ELZ measuring from the termination point of the approach to the junction at the road.

Enter + for a positive or uphill gradient and - for a negative or down hill gradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

AID-77 Enter the code that best describes improvements used on any portion of the water drafting approach in Approach Area A-Inside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as geo-textile, pallets, mats, slash, corduroy etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

AID-78 Enter the code that best describes the water drafting approach's construction adjacnt to Approach Area A – Inside the WLPZ/ELZ

1. Created by cut and fill construction.
2. Created by full bench construction.
3. Created by through fill.
4. Created by through cut.
5. Created with no cut or fills (i.e. flat ground)

AID-79 Is there evidence of petroleum or petroleum residue on the water drafting approach adjacent to Approach Area A – Inside the WLPZ/ELZ?

1. Yes. (go to AID-80)
2. No. (go to AID-81)

AID-80 Enter the diameter in feet or decimal fractions of a foot of the area occupied by the petroleum or petroleum residue.

AID-81 Does runoff from Approach Area A – Inside the WLPZ/ELZ flow to or across the water drafting approach.

1. Yes. (go to AID-82)
2. No. (go to AID-83)

AID-82 Are there sediment deposits on the water drafting approach adjacent to Approach A – Inside the WLPZ/ELZ?

1. Yes.
2. No.

AID-83 Enter the code that best describes any soil movement on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bankfull width of the channel. (go to question AID-84)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bankfull width of the channel. (go to question AID-84)
3. Soil moved on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ, but did not reach the water body nor to within the bankfull width of the channel. (go to question AID-93)
4. Soil is stabilized on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ (go to question AID-100)
5. Soil movement occurs on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ, but has been recorded elsewhere in the protocol. (go to question GC-101)

<u>Sediment deposited in the water body from the water drafting approach in Approach Area A-Inside the WLPZ/ELZ</u>

AID-84 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from the water drafting approach in Approach Area A-Inside the WLPZ/ELZ.

1. Ditch or rut (wheel, track, log drag, etc). (go to question AID-85)
2. Gully (go to question AID-85)
3. Rill (go to question AID-85)
4. Sheet flow, sediment deposition trail or alluvial fan (go to question AID-87)
5. Soil slumping or dropping (go to question AID-87)
6. Mechanical deposition of soil. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question AID-87)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form evolves into another in a continuous manner such as when a rill becomes a gully, record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut, etc.

AID-85 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question AID-84.

Where one erosion form evolves into another in a continuous manner, such as when a rill becomes a gully, measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

AID-86 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question AID-84.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

AID-87 Enter the currently evident volume of sediment deposited in the water body or to within the bankfull width of the channel in whole cubic yards by the delivery system identified in question AID-84.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole cubic yards.

Enter “0” if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

AID-88 Enter the code that best describes the predominant type of sediment delivered to the water body or to within the bankfull width of the channel by the delivery system identified in question AID-84.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 inches)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AID-89 Can sedimentation be expected to occur during the next storm event based on your answers above?

1. Yes.
2. No.
3. Unknown.

AID-90 Were principles / practices applied?

1. Yes.
2. No.

AID-91 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AID-92 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from the water drafting approach in Approach Area A-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question GC-101

Soil moved on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ, but did not reach the water body

AID-93 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

AID-94 Enter the code that best describes the evidence that soil moved, but did not reach the water body nor to within the bankfull width of the channel from the water drafting approach in Approach Area A-Inside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion form continuously evolves into another(such as when a rill becomes a gully) record the predominant form.

AID-95 Enter the code that best describes the predominant type of soil that was moved, but did not reach the water body nor to within the bankfull width of the channel by the delivery system identified in question AI75.21.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

AID-96 Can sedimentation be expected to occur during the next storm event based on your answers to questions?

1. Yes.
2. No.
3. Unknown.

AID-97 Were principles / practices applied?

1. Yes.
2. No.

AID-98 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

AID-99 Enter the code that best describes the specific cause of soil movement on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question GC-101

<u>Soil stabilized on the water drafting approach in Approach Area A-Inside the WLPZ/ELZ</u>

AID-100 Were principles / practices applied?

1. Yes.
2. No.

After answering question AID-100 proceed directly to question GC-101

CROSSING STRUCTURE

GC-101 Enter the code that describes the current crossing status.

1. New—permanent
2. Pre-existing—permanent
3. New—temporary
4. Pre-existing—temporary
5. Abandoned/removed

GC-102 Is there evidence that the crossing has been maintained since the last winter period?

1. Yes.
2. No.

GC-103 Is there perched fill material at the inlet or outlet of the crossing within or immediately adjacent to bankfull.

1. Yes.
2. No.

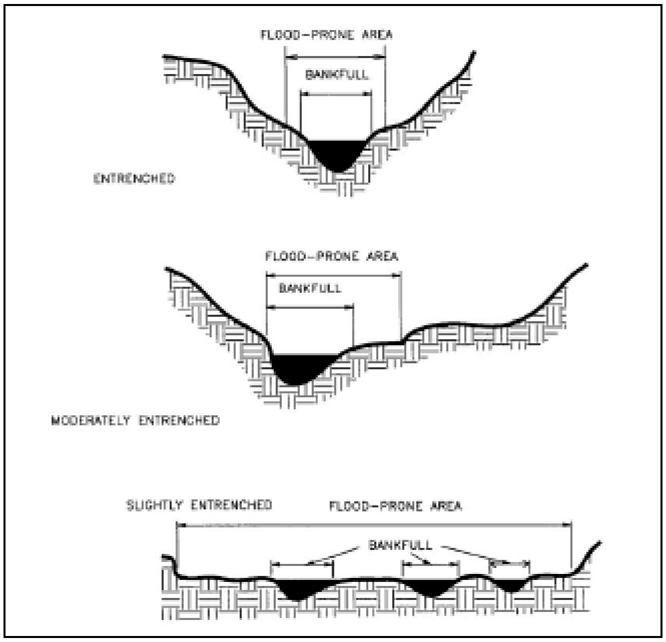
GC-104 Enter the active channel bed width in feet (measured at a riffle).

GC-105 Enter the bankfull channel width in feet (measured at a riffle).

GC-106 Enter the bankfull depth in feet (measured at a riffle).

GC-107 Enter the code best describing the entrenchment of the natural watercourse channel above the crossing.

1. Entrenched (Confined)
2. Moderately entrenched (Unconfined)
3. Slightly entrenched (Braided)



GC-108 Enter the code best describing the average percent grade of the natural watercourse channel above and below the crossing.

1. 0-2%
2. 2-4%
3. 4-10%
4. 10-30%
5. > 30%

GC-109 Enter the code indicating if a crossing was impacted by a landslide after its construction.

1. Yes.
2. No.

GC-110 Enter the code that best describes the crossing structure.

1. Single-pipe culvert (Go to C-111)
   This type of culvert may have an overflow pipe and would not qualify as a multiple pipe crossing. The crossing shall be treated as a single pipe crossing.
2. Multiple culverts (Go to C-130)
3. Pipe arch (Go to C-111)
4. Arch bottomless (Go to C-138)
5. Native Surfaced Ford (Go to C-142)
6. Dry Ford – rocked outfall (Go to C-144)
7. Wet Ford – rocked outfall and surface (Go to C-144)
8. Arizona crossing/vented ford (Go to C-111)
9. Ford with concrete apron (Go to C-144)
10. Temporary crossing (Go to C-151)
11. French drains/burrito crossing (Go to C-160)
12. Bridge – closed top (Go to C-147)
13. Bridge – open planked top (Go to C-147)
14. Other (Go to C-160)

<u>Culverted Crossing</u>

C-111 Enter the code that describes the culvert/pipe arch/arch entrance type.

1. Projecting pipe
2. Pipe end mitered
3. Headwall
4. Headwall and wingwalls (concrete and/or rock)
5. Flared metal inlet
6. Not applicable

C-112 Enter the code describing whether a critical dip was installed at the crossing.

1. A critical dip is installed, and has experienced flow from the crossing, and did erode or down cut
2. A critical dip is installed, has experienced flow from the crossing, and did not erode or down cut
3. A critical dip is installed at the crossing and there is no indication of flow
4. No critical dip was installed (go to C-113)

C-113 Is there diversion potential at the crossing? Diversion is defined as the ability for the watercourse to be channeled down the road for a distance greater than the WLPZ/ELZ width.

1. There is potential, but no physical evidence for watercourse diversion down the road.
2. There is potential and physical evidence of flow down the road.
3. There is no potential for watercourse diversion due to crossing design or topographical features.
4. Design accommodates for potential of overflow (i.e. significantly oversized culvert installed).

C-114 Enter the number of pipes present at the crossing site.

C-115 Enter the diameter, in inches, of the channel pipe present at the crossing site.

C-116 Enter the code that describes the pipe gradient.

1. Similar to natural channel slope
2. Significantly lower gradient, compared to natural channel slope
3. Significantly higher gradient

C-117 Enter code indicating the percentage of the pipe inlet area that is currently blocked by wood and/or sediment.

1. 0-10%
2. 11-25%
3. 26-50%
4. >50%

C-118 Enter the code indicating if there is a trash rack installed.

1. Yes
2. No

C-119 Enter the code that describes the horizontal alignment of the pipe present.

1. In line with channel
2. Offset from channel
3. Skewed

C-120 Enter the code that describes the degree of deformation of the pipe.

1. No significant deformation
2. Pipe deformed <10%.
3. Pipe deformed >10%.

C-121 Is the pipe length adequate?

1. Yes.
2. No.

C-122 Is the fill over the pipe centered on the pipes length?

1. Yes.
2. No.

C-123 Is the fill face over steepened on either side of the pipe?

1. Yes.
2. No.

C-124 Is the pipe located on a Class I fish bearing watercourse?

1. Yes (go to C-125)
2. No (go to C-160)

C-125 Enter the code indicating depth of the residual pool at the inlet in inches.

1. < 6”
2. ≥ 6”

C-126 Enter the code indicating if there is streambed substrate throughout the pipe.

1. Yes
2. No

C-127 Enter the code indicating if the pipe includes baffles or weirs.

1. Yes
2. No

C-128 Enter the code indicating if there is a pool at the outlet.

1. Yes
2. No

C-129 Enter the code indicating pipe outlet drop in inches.

1. 0-11”
2. 12-24”
3. >24”

After answering C-129, go to C-160

<u>Multiple Pipes</u>

C-130 Enter the code that describes the culverts entrance types.

1. Projecting pipe
2. Pipe end mitered
3. Headwall
4. Headwall and wingwalls (concrete and/or rock)
5. Flared metal inlet
6. Not applicable

C-131 Enter the code describing whether a critical dip was installed at the crossing.

1. A critical dip is installed, and has experienced flow from the crossing, and did erode or down cut
2. A critical dip is installed, has experienced flow from the crossing, and did not erode or down cut
3. A critical dip is installed at the crossing and there is no indication of flow
4. No critical dip was installed (go to C-132)

C-132 Is there diversion potential at the crossing? Diversion is defined as the ability for the watercourse to be channeled down the road for a distance greater than the WLPZ/ELZ width.

1. There is potential, but no physical evidence for watercourse diversion down the road.
2. There is potential and physical evidence of flow down the road.
3. There is no potential for watercourse diversion due to crossing design or topographical features.
4. Design accommodates for potential of overflow (i.e. significantly oversized culvert installed).

C-133 Enter the number of pipes present at the crossing site.

C-134 Enter the percentage of the pipe inlet area that is currently blocked by wood and/or sediment (0 to 100%).

C-135 Enter the code that describes the horizontal alignment of the pipe present.

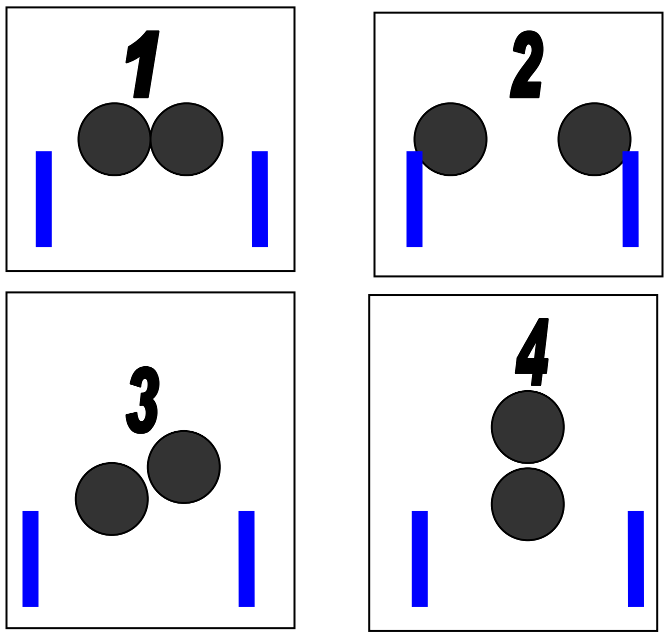
1. In line with channel
2. Offset from channel
3. Skewed

C-136 Is there a trash rack associated with the crossing?

1. Yes
2. No.

C-137 Which diagram below most closely resembles the arrangement of the multiple pipes at the crossing location relative to bankfull (vertical, parallel lines)?

1. 1
2. 2
3. 3
4. 4



After answering C-137, go to C-160

Bottomless Arch Crossing

C-138 Enter the code that describes the arch entrance type.

1. Projecting pipe
2. Pipe end mitered
3. Headwall
4. Headwall and wingwalls (concrete and/or rock)
5. Flared metal inlet
6. Not applicable

C-139 Enter the span, in feet, of the arch.

C-140 Enter the height, in feet, of the arch.

C-141 Enter the code that describes stream channel stability within the crossing structure.

1. Stable
2. Scouring laterally
3. Down-cutting
4. Aggrading
5. Other

After answering C-141 go to C-160

<u>Native Surfaced Ford Crossing</u>

C-142 Is the ford constructed to handle the flows experienced at the crossing as evidenced by containment of flow within the constructed width?

1. Yes.
2. No.

C-143 Enter the code(s) for observed erosion at fords.

1. Road surface channelization >2"
2. Gullied outfall
3. Gullied outfall at edge of armor
4. Gully/surface channelization out of ford (diversion)
5. None or minimal erosion
6. Other

After answering C-143, go to C-160

<u>Wet/Dry Ford Crossings</u>

C-144 Is the ford constructed to handle the flows experienced at the crossing as evidenced by containment of flow within the constructed width?

1. Yes.
2. No.

C-145 Enter the code(s) for observed erosion at fords.

1. Road surface channelization >2”
2. Gullied outfall
3. Gullied outfall at edge of armor
4. Gully/surface channelization out of ford (diversion)
5. None or minimal erosion
6. Other

C-146 Does at least 50% (by volume) of the rock used for the constructed outfall equal or exceed the stable rock sizes observed in the watercourse channel upstream/ downstream of the ford?

1. Yes
2. No
3. Indeterminate

After answering C-146, go to C-160

<u>Bridge Crossings</u>

C-147 Enter code that describes the predominant bank protection under the bridge.

1. Concrete
2. Rip-rap
3. Steel sheeting
4. Wood/timber
5. Log
6. Concrete filled CMPs
7. None
8. Other

C-148 Enter the code that describes bridge alignment.

1. Perpendicular to the waterbody.
2. Skewed to the waterbody.

C-149 Enter the code that describes bridge length.

1. The bridge is long with adequate turning radius.
2. The bridge is short with adequate turning radius.

C-150 Enter code that describes stream channel stability at the crossing.

1. Stable
2. Scouring laterally
3. Down-cutting
4. Aggrading
5. Other

After answering C-150, go to C-160

Removed or Abandoned Crossings

C-151 Enter the code that indicates if the crossing has been excavated to form a channel that is similar to the natural watercourse grade and orientation and is wider than the natural channel.

1. Yes.
2. No.

C-152 Are there erosional processes occurring at the removed or abandoned crossing site?

1. Yes (Go to C120)
2. No (Go to C-160)

C-153 Are slumps/debris slides present?

1. Yes.
2. No.

C-154 Is there evidence of channel incision?

1. Yes.
2. No.

C-155 Is the watercourse headcuting through the crossing location?

1. Yes.
2. No.

C-156 Was a grade control structure installed?

1. Yes.
2. No.

C-157 Are there gullies present at the crossing location?

1. Yes.
2. No.

C-158 Is there surface erosion and rilling at the crossing location?

1. Yes.
2. No.

C-159 Is there bank erosion at the crossing location?

1. Yes.
2. No.

After answering C-159, go to C-160

C-160 Enter the code that best describes the structure bottom and stream substrate used

1. Open bottom structure or structure removed
2. Closed bottom structure, natural streambed substrate material is present and continuous on the inside bottom of the structure
3. Closed bottom structure, natural streambed substrate material is not present or not continuous on the inside bottom of the structure

C-161 Enter the code that best describes the most significant type of bank protection both upstream and downstream.

1. Rip-rap
2. Gabions
3. Wing-walls
4. Vegetation
5. Seeded/Mulched
6. Slash/wood
7. Naturally stable due to substrate
8. None
9. Other

C-162 Enter the code that best describes the fill face armoring present on the inlet side.

1. Rock armored
2. Partially rock armored around the pipe only
3. Slash armored
4. Not armored but mulched and/or seeded
5. Not armored but supports brush and/or trees
6. Not armored but supports grass and/or forbs
7. Not armored and exposed bare soil
8. Not applicable

C-163 Enter the code that best describes the fill face armoring present on the outlet side.

1. Rock armored
2. Partially rock armored around the pipe only
3. Slash armored
4. Not armored but mulched and/or seeded
5. Not armored but supports brush and/or trees
6. Not armored but supports grass and/or forbs
7. Not armored and exposed bare soil
8. Not applicable

C-164 Is the crossing structure opening, or stream channel in the event the structure has been removed, equal to or greater than the pre-structure bankfull channel width?

1. Yes.
2. No.

C-165 Enter the code indicating if the size of the crossing structure opening meets state requirements at the time of plan approval.

1. Yes.
2. No.
3. Unknown.

C-166 Enter the code indicating if there is evidence of stream down cutting, scouring, or aggradation within 100 feet downstream of the outlet end of the structure

1. Evidence of scouringand downcutting.
2. Evidence of aggrading or widening.
3. Stable.

C-167 Enter the code indicating if there is evidence of stream down cutting, scouring, or aggradation within 100 feet upstream of the inlet end of the structure

1. Evidence of scouringand downcutting.
2. Evidence of aggrading or widening.
3. Stable.

C-168 Enter the code indicating whether the following conditions exist near the crossing (the most prevalent).

1. No significant hazards observed
2. Significant wood accumulations near crossing
3. Significant bedload accumulations threatening crossing
4. Significant wood and sediment accumulations threatening crossing
5. Sizing inadequate (main hazard present)
6. Other (describe)

C-169 Have modifications been made to the crossing, for purposes such as water drafting, which have impacted the functionality of the crossing?

1. No
2. Yes
3. Yes (1600 agreement)
4. Unknown

C-170 Enter the code that best describes soil or fill material movement or mechanical deposition of fill material associated with the crossing structure

1. Measurable amounts of sediment deposited in the water body (go to question C-171).
2. Trace amounts such as films or suspended sediments visible in the water body. (go to question C-171)
3. Soil moves, but does not reach the water body. (go to question C-182)
4. Soil stabilized at crossing. (go to question C-185)
5. Soil movement occurs, but has been recorded elsewhere in the protocol. (go to question BG-186)

In cases where the sediment delivery system (C-171) indicates strongly that measurable volumes of sediment have been deposited in the water body, but have since been washed away, enter “1” for question C-171 and enter “0” for question C-176.

Note that the crossing structure includes only that area within the bankfull width of the channel.

Inspect the structure and any associated fill or abutments that are within the bankfull width of the channel.

Look for evidence of soil movement such as rills, gullies or other sediment trails. Consider also material moved by machines during construction as well as material pushed by wheels or dragged by logs. Material on the deck of bridges within the bankfull width of the channel is considered to be deliverable in the water body.

Depending on the time of year it may be necessary to brush away newly fallen leaves to follow the sediment trail. Sediment occurring above or below the various leaf layers will provide clues as to whether the erosion occurred during a prior harvest or is ongoing.

Only one code can be entered. Consider the various problems evident and report on the worst case scenario choosing the answer codes that best describe the situation.

Soil Delivered to the Water Body from the Crossing Structure.

C-171 Enter the code that best describes the evidence that sediment was delivered to the water body.

1. Ditch or rut (wheel, track, log drag, etc.) (Go to question C-172)
2. Gully. (Go to question C-172)
3. Rill. (Go to question C-172)
4. Sheet flows, soil puddling or deposition trail. (Go to question C-174)
5. Soil slumping, piping, leaching, weeping, falling. (Go to question C-174)
6. Mechanical deposition of soil. Example: Soil pushed into the waterbody or onto temporary crossing structures by machinery or dragged logs. (Go to question C-174)
7. Undercutting of crossing structure (Go to question C-174)
8. Overflow or total washout of the crossing structure (Go to question C-174)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form continuously evolves into another in a continuous manner (such as when a rill becomes a gully) record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut etc.

C-172 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question C-171.

Where one erosion form evolves into another in a continuous manner, such as when a rill becomes a gully, measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

C-173 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question C-171.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

C-174 Is the erosion occurring on a fill face?

1. Yes (go to C-175)
2. No (go to C-176)
3. Not applicable (go to C-176)

C-175 Enter the code describing the source of flow causing fill face erosion.

1. The fill face is eroded by overtopping of the crossing by streamflow.
2. The fill face is eroded by accumulated flow from road surfaces.
3. The fill face is eroded by both overtopping and accumulated flow from road surfaces.
4. Over steepened fill faces.
5. Perched fills.

C-176 Enter the currently evident volume of sediment deposited in the water body width of the channel in whole cubic decimal yards by the delivery system identified in question C-171.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole cubic feet.

Enter "0" if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

.

C-177 Enter the code that best describes the predominant type of material delivered to the water body by the delivery system identified in question C136.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

C-178 Is sedimentation expected to continue to occur during the next storm event based on your answers to questions C-171 through C-177?

1. Yes.
2. No.
3. Unknown.

C-179 Were principles / practices applied?

1. Yes.
2. No.

C-180 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

C-181 Enter the code that best describes the specific cause of soil movement in Approach Area A-Inside the WLPZ/ELZ.

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

After answering question C-181 proceed directly to question BG-186

Soil Moves but does not reach the Water Body

C-182 Were principles / practices applied?

1. Yes.
2. No.

C-183 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

C-184 Enter the code that best describes the specific cause of soil movement in Approach Area A-Inside the WLPZ/ELZ.

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

After answering question C-184 proceed directly to question BG-186

Quality Practices and Principles Applied for Crossing Structure

C-185 Were principles / practices applied?

1. Yes.
2. No.

After answering question C-185 proceed directly to question BG-186

WATER BODY CROSSING APPROACH AREA B

BG-186 Enter the WLPZ/ELZ width in whole feet based on plan or Forest Practice Rules for approach B of the water body being crossed.

BG-187 Enter the code that describes the current road/skid trail status.

1. New
2. Existing
3. Reconstructed
4. Abandoned

BG-188 Enter the code indicating the road type.

1. Permanent road
2. Seasonal road
3. Temporary road
4. Skid Trail

Approach Area B-Outside the WLPZ/ELZ

Establish the protocol survey area on Approach Area A by measuring the distance on the road surface equivalent to 3X the WLPZ/ELZ width or 300 feet, whichever is less. Distances are measured from bank full.

If within this distance, there are topographic features or a change in grade that prohibits road drainage from draining to the subject watercourse, the upland boundary of the protocol survey area is established at that point. This change is not applicable for drainage facilities including waterbreaks or rolling dips and the change must be continuous throughout the remainder of the measured distance.

BO-189 Does Approach Area A exit the WLPZ/ELZ within this distance?

1. If yes, go to BO-190.
2. If no, go to BI-213

Approach Area B-Outside the WLPZ/ELZ DEFINED

Approach Area B-Outside the WLPZ/ELZ originates at the upland edge of the WLPZ/ELZ and extends inland perpendicular to the bank to the edge of the protocol survey area. When road runoff drains away from the watercourse crossing, the protocol survey area is truncated at that point and further survey beyond that point is not necessary. For this purpose, ignore road drainage facilities such as waterbreaks or rolling dips.

If there is no WLPZ/ELZ, limit the approach area outside the WLPZ/ELZ to 25 feet.

Observe the conditions on the ground within Approach Area B-Outside the WLPZ/ELZ and answer the questions. You may have to follow some indicators such as rills, ruts or gullies into the approach area inside the buffer or into the water body itself to answer the questions.

BO-190 Enter the code that best describes the road prism Approach Area B – Outside the WLPZ/ELZ

1. Landing adjoining maintained road.
2. Road/trail insloped with no inside ditch.
3. Road/trail insloped with an inside ditch.
4. Road/trail outsloped with no inside ditch.
5. Road/trail outsloped with an inside ditch
6. Road/trail crowned with an inside ditch.
7. Road/trail crowned with no inside ditch
8. Road/trail inverted below general grade of adjoining land (includes through cuts and roads on flat ground).
9. Road/trail bermed with no inside ditch.
10. Road/trail bermed with an inside ditch.

BO-191 Enter the code that best describes the road construction at Approach Area B – Outside the WLPZ/ELZ

1. Road/trail profile created by cut and fill construction.
2. Road/trail profile created by full bench construction.
3. Road/trail profile created by through fill.
4. Road/trail created by through cut.
5. Road/trail created with no cut or fills (i.e. road on flat ground)

BO-192 Is the drainage from the road surface of Approach Area A – Outside the WLPZ/ELZ diverted off the road prism by a drainage facility before it reaches the crossing?

1. Yes
2. No
3. Not applicable, crossing is higher in elevation than Approach Area B.

BO-193 Enter the code that best describes predominant improvements used on any portion of the road / trail in Approach Area B-Outside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as geo-textile, pallets, mats, slash, corduroy etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

BO-194 Enter the percent grade of the road / trail in Approach Area B- WLPZ/ELZ measuring from the upland edge of the WLPZ/ELZ at the crossing

Enter + for a positive or upgradient and - for a negative or downgradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

BO-195 Enter the code that best describes any soil movement on Approach Area B-Outside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bank full width of the channel. (go to question BO-196)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bank full width of the channel. (go to question BO-196)
3. Sediment was deposited inside the WLPZ/ELZ, but did not reach the water body or within the bank full width of the channel. (go to question BO-205)
4. Soil moved in Approach Area B-Outside the WLPZ/ELZ, but did not reach the WLPZ/ELZ. (go to question BI-213)
5. Soil is stabilized for Approach Area B-Outside the WLPZ/ELZ (go to question BO-212)

In cases where the sediment delivery system (BO-196) indicates strongly that measurable volumes of sediment have been deposited in the water body, but have since been washed away, enter “1” for question BO-195 and enter “0” for question BO-199.

Locate the boundaries of the area in question and carefully inspect the road or trail as well as the ditches and adjoining cut or fill slopes.Look for evidence of soil movement such as rills, gullies or other sediment trails. Consider also material moved by machines during construction as well as material pushed by wheels or dragged by logs.

Depending on the time of year it may be necessary to brush away newly fallen leaves to follow the sediment trail. Sediment occurring above or below the various leaf layers will provide clues as to whether the erosion occurred during a prior harvest or is ongoing.

Only one code can be entered. Consider the various problems evident and report on the worst case scenario choosing the answer codes that best describe the situation.

Sediment deposited in the water body from Approach Area-B, Outside the WLPZ/ELZ

BO-196 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from Approach Area B-Outside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc. (go to question BO-197)
2. Gully (go to question BO-197)
3. Rill (go to question BO-197)
4. Sheet flow, sediment deposition trail or alluvial fan (go to question BO-199)
5. Soil slumping or dropping (go to question BO-199)
6. Mechanical deposition. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question BO-199)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form continuously evolves into another (such as when a rill becomes a gully), record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut etc.

BO-197 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question BO-196.

Where one erosion form continuously evolves into another (such as when a rill becomes a gully), measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

BO-198 Enter the mid point cross sectional area, in whole square inches of the rill, gully, ditch or rut identified in question BO-196.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

BO-199 Enter the currently evident volume of sediment deposited in the water body or within the bankfull width in whole cubic yards by the delivery system identified in question BO-196.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole yards.

Leave zero if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

BO-200 Enter the code that best describes the preponderant type of sediment delivered to the water body or within the bankfull width of the channel by the delivery system identified in question BO-196.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BO-201 Can sedimentation be expected to occur during the next storm event based on your answers to questions BO-196 through BO-200?

1. Yes.
2. No.
3. Unknown.

BO-202 Were principles / practices applied?

1. Yes.
2. No.

BO-203 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BO-204 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from Approach Area B-Outside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering proceed directly to question BI-213.

Sediment deposited inside the WLPZ/ELZ, but not the water body from Approach Area B-Outside the WLPZ/ELZ

BO-205 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

BO-206 Enter the code that best describes the evidence that sediment reached the WLPZ/ELZ but not the water body nor to within the bankfull width of the channel from Approach Area B-Outside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion feature continuously evolves into another (such as when a rill becomes a gully) record the dominant form.

BO-207 Enter the code that best describes the preponderant type of sediment delivered to the WLPZ/ELZ but not the water body nor to within the bankfull width of the channel by the delivery system identified in question BO-206.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BO-208 Can sedimentation be expected to occur during the next storm event based on your answers to questions BO-205 and BO-207.

1. Yes.
2. No.
3. Unknown.

BO-209 Were principles / practices applied?

1. Yes.
2. No.

BO-210 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BO-211 Enter the code that best describes the specific cause of sediment delivery to the WLPZ/ELZ, but not the water body nor to within the bankfull width of the channel from Approach Area B-Outside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation

After answering proceed directly to question BI-213

<u>Soil stabilized in Approach Area-B, Outside the WLPZ/ELZ</u>

BO-212 Were principles / practices applied?

1. Yes.
2. No.

After answering question BO-212 and reading the following explanation proceed directly to question BI-213

Approach Area B-Inside the WLPZ/ELZ

Approach Area B-Inside the WLPZ/ELZ originates at the outer edge of the stream's bankfull and extends to the outer edge of the WLPZ/ELZ.

Observe the conditions on the ground within Approach Area B-Inside the WLPZ/ELZ and answer the questions.

Report only those conditions that originate from the approach area inside the buffer. Conditions originating beyond the approach area inside the buffer were reported in the previous section.

BI-213 Is there a WLPZ/ELZ?

1. Yes, go to BI-214.
2. No, go to O-265

BI-214 Enter the percent grade of the road / trail in Approach Area B Inside WLPZ/ELZ measuring from the bankful width of the water body at the crossing.

Enter + for a positive or uphill gradient and - for a negative or down hill
gradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

BI-215 Enter the code that best describes improvements used on any portion of the road / trail in Approach Area B-Inside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as Geo-textile, pallets, mats, slash, corduroy, etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

BI-216 Enter the code that best describes the road prism Approach Area B – Inside the WLPZ/ELZ

1. Landing adjoining maintained road.
2. Road insloped with no inside ditch.
3. Road insloped with an inside ditch.
4. Road outsloped with no inside ditch.
5. Road outsloped with an inside ditch
6. Road crowned with an inside ditch.
7. Road crowned with no inside ditch
8. Road inverted below general grade of adjoining land (includes through cuts and roads on flat ground).
9. Road bermed with no inside ditch
10. Road bermed with inside ditch.

BI-217 Enter the code that best describes the road construction Approach Area B – Inside the WLPZ/ELZ

1. Road/trail profile created by cut and fill construction.
2. Road/trail profile created by full bench construction.
3. Road/trail profile created by through fill.
4. Road/trail created by through cut.
5. Road/trail created with no cut or fills (i.e. flat ground)

BI-218 Is the drainage from the road surface Approach Area B – Inside the WLPZ/ELZ diverted off the road prism by a drainage facility before it reaches the crossing by a drainage structure or facility.

1. Yes
2. No
3. Not applicable, crossing is higher in elevation than Approach Area B.

BI-219 Enter the code that best describes any soil movement on Approach Area B-Inside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bankfull width of the channel. (go to question BI-220)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bankfull width of the channel. (go to question BI-220)
3. Soil moved in Approach Area-B, Inside the WLPZ/ELZ, but did not reach the water body or within the bankfull width of the channel. (go to question BI-229)
4. Soil is stabilized for Approach Area-B, Inside the WLPZ/ELZ (go to question BI-236)
5. Soil movement occurs in Approach Area-B, Inside the WLPZ/ELZ, but has been recorded elsewhere in the protocol. (go to question BI-237)

In cases where the sediment delivery system (BI-220) indicates strongly that measurable volumes of sediment have been deposited in the water body, but have since been washed away, enter “1” for question BI-219 and enter “0” for question BI186.

Locate the boundaries of the area in question and carefully inspect the road or trail as well as the ditches and adjoining cut or fill slopes.
Look for evidence of soil movement such as rills, gullies or other sediment trails. Consider also material moved by machines during construction as well as material pushed by wheels or dragged by logs.

Depending on the time of year it may be necessary to brush away newly fallen leaves to follow the sediment trail. Sediment occurring above or below the various leaf layers will provide clues as to whether the erosion occurred during a prior harvest or is ongoing.

Only one code can be entered. Consider the various problems evident and report on the worst case scenario choosing the answer codes that best describe the situation.

Sediment deposited in the water body from Approach Area B Inside the WLPZ/ELZ

BI-220 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from Approach Area B-Inside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc). (go to question BI-221)
2. Gully. (go to question BI-221)
3. Rill. (go to question BI-221)
4. Sheet flow, sediment deposition trail or alluvial fan. (go to question BI-223)
5. Soil slumping or dropping. (go to question BI-223)
6. Mechanical deposition of soil. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question BI-223)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form evolves into another in a continuous manner such as when a rill becomes a gully, record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut etc.

BI-221 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question BI-220.

Where one erosion form evolves into another in a continuous manner, such as when a rill becomes a gully, measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

BI-222 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question BI-220.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

BI-223 Enter the currently evident volume of sediment deposited in the water body or within the bankfull width of the channel in whole cubic yards by the delivery system identified in question BI-220.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole cubic yards.

Enter "0" if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

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BI-224 Enter the code that best describes the predominant type of sediment delivered to the water body or to within the bankfull width of the channel by the delivery system identified in question BI-220.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 inches)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BI-225 Can sedimentation be expected to occur during the next storm event based on your answers to questions BI-220 through BI-224.

1. Yes.
2. No.
3. Unknown.

BI-226 Were principles / practices applied?

1. Yes.
2. No.

BI-227 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BI-228 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from Approach Area B-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question BI-237

<u>Soil Moved In Approach Area B-WLPZ/ELZ, but did not reach the water body</u>

BI-229 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

BI-230 Enter the code that best describes the evidence that soil moved, but did not reach the water body nor to within the bankfull width of the channel from within Approach Area B-Inside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion form continuously evolves into another (such as when a rill becomes a gully) record the predominant form.

BI-231 Enter the code that best describes the preponderant type of soil that was moved but did not reach the water body nor to within the bankfull width of the channel by the delivery system identified in question BI-230.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BI-232 Can sedimentation be expected to occur during the next storm event based on your answers to questions BI-230 and BI-231.

1. Yes.
2. No.
3. Unknown.

BI-233 Were principles / practices applied?

1. Yes.
2. No.

BI-234 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BI-235 Enter the code that best describes the specific cause of soil movement that did not reach the water body nor to within the bankfull width of the channel in Approach Area B-Inside the WLPZ/ELZ.

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question BI-237

Soil stabilized In Approach Area B-Inside the WLPZ/ELZ

BI-236 Were principles / practices applied?

1. Yes.
2. No.

After answering question BI-236 proceed directly to question BI-237

BI-237 Enter the code that best describes the preponderant hydrologic soil type in Approach Area B-WLPZ/ELZ

1. Type A (sand/gravel - feels gritty)

2. Type B/C (loams – feels crumbly)
3. Type D (silt, clay, muck – smooth, plastic to gelatinous)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

Water Drafting - Approach Area-A, Inside the WLPZ/ELZ

BID-238 Is there a water drafting approach constructed in Approach Area B – Inside the WLPZ/ELZ

1. Yes. (If yes, go to BID-239)
2. No. (If no, go to O-265)

BID-239 Enter the length, in feet, of the water drafting approach constructed in Approach Area B – Inside the WLPZ/ELZ

BID-240 Enter the percent grade of the water drafting approach in Approach Area B Inside the WLPZ/ELZ measuring from the termination point of the approach to the junction at the road.

Enter + for a positive or uphill gradient and - for a negative or down hill gradient followed by the percent grade in whole numbers.

Example: a 15% uphill grade as seen from the crossing would code +15. A 17% downhill grade would code -17

BID-241 Enter the code that best describes improvements used on any portion of the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

1. Native material construction, no improvement evident.
2. Erosion control methods/improvements added such as geo-textile, pallets, mats, slash, corduroy etc.
3. Permeable surfacing material such as gravel added
4. Non-permeable paving such as asphalt or concrete
5. Other

BID-242 Enter the code that best describes the water drafting approach's construction adjacnt to Approach Area B – Inside the WLPZ/ELZ

1. Created by cut and fill construction.
2. Created by full bench construction.
3. Created by through fill.
4. Created by through cut.
5. Created with no cut or fills (i.e. flat ground)

BID-243 Is there evidence of petroleum or petroleum residue on the water drafting approach adjacent to Approach Area B – Inside the WLPZ/ELZ?

1. Yes. (go to BID-244)
2. No. (go to BID-245)

BID-244 Enter the diameter in feet or decimal fractions of a foot of the area occupied by the petroleum or petroleum residue.

BID-245 Does runoff from Approach Area B – Inside the WLPZ/ELZ flow to or across the water drafting approach.

1. Yes. (go to BID-246)
2. No. (go to BID-247)

BID-246 Are there sediment deposits on the water drafting approach adjacent to Approach A – Inside the WLPZ/ELZ?

1. Yes.
2. No.

BID-247 Enter the code that best describes any soil movement on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

1. Measurable amounts of sediment deposited in the water body or within the bankfull width of the channel. (go to question BID-248)
2. Trace amounts such as films or suspended sediments deposited in the water body or within the bankfull width of the channel. (go to question BID-248)
3. Soil moved on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ, but did not reach the water body nor to within the bankfull width of the channel. (go to question BID-257)
4. Soil is stabilized on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ (go to question BID-264)
5. Soil movement occurs on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ, but has been recorded elsewhere in the protocol. (go to question O-265)

Sediment deposited in the water body from the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

BID-248 Enter the code that best describes the evidence that sediment reached the water body or to within the bankfull width of the channel from the water drafting approach in Approach Area B-Inside the WLPZ/ELZ.

1. Ditch or rut (wheel, track, log drag, etc). (go to question BID-249)
2. Gully (go to question BID-249)
3. Rill (go to question BID-249)
4. Sheet flow, sediment deposition trail or alluvial fan (go to question BID-251)
5. Soil slumping or dropping (go to question BID-251)
6. Mechanical deposition of soil. Examples include soil pushed into the bankfull channel or onto a bridge by machinery or dragged logs. (go to question BID-251)

Only one code can be entered. Record the worst case scenario.

Read all of the answers and eliminate the ones that do not apply to arrive at the answer that best describes the situation.

Where one erosion form evolves into another in a continuous manner such as when a rill becomes a gully, record the predominant form. Report the evidence consistent with the definitions in Appendix A for terms such as rill, gully, wheel rut, etc.

BID-249 Enter the total length in whole feet of the rill, gully, ditch or rut identified in question BID-248.

Where one erosion form evolves into another in a continuous manner, such as when a rill becomes a gully, measure and record the total length of the combined forms of erosion. If the rill or gully is branched measure only the length of the main section. For an inside ditch, measure the entire length of the ditch, even if it extends outside of the protocol survey area. Do not add the lengths of the branches. Accurate pacing is acceptable for measurement.

BID-250 Enter the mid point cross sectional area in whole square inches of the rill, gully, ditch or rut identified in question BID-248.

Locate a typical cross section at approximately the halfway point in the combined length of the rill, gully or other formation being reported. Place a straightedge across the top of the eroded zone and measure the width and depth in inches.

BID-251 Enter the currently evident volume of sediment deposited in the water body or to within the bankfull width of the channel in whole cubic yards by the delivery system identified in question BID-248.

Look upstream and down and determine by color, texture and location that the sediment deposit originates from the delivery system described in the three previous questions. Probe the deposit in several places to determine the average depth and measure the length and width to determine the volume.

Record the volume in whole cubic yards.

Enter “0” if sediment has been completely flushed away or if reasonably accurate measurement of existing deposit is not possible.

BID-252 Enter the code that best describes the predominant type of sediment delivered to the water body or to within the bankfull width of the channel by the delivery system identified in question BID-248.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 inches)
7. Sediment deposited in the water body has washed away; therefore, the type is unknown.

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BID-253 Can sedimentation be expected to occur during the next storm event based on your answers above?

1. Yes.
2. No.
3. Unknown.

BID-254 Were principles / practices applied?

1. Yes.
2. No.

BID-255 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BID-256 Enter the code that best describes the specific cause of sediment delivery to the water body or to within the bankfull width of the channel from the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question O-265

Soil moved on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ, but did not reach the water body

BID-257 Enter the distance from the watercourse that the sediment terminated.

Measure horizontal distance in whole feet perpendicular to the bank.

BID-258 Enter the code that best describes the evidence that soil moved, but did not reach the water body nor to within the bankfull width of the channel from the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

1. Ditch or rut (wheel, track, log drag, etc)
2. Gully
3. Rill
4. Sediment deposition trail, sheet flow, or alluvial fan
5. Soil slumping or dropping
6. Mechanical deposition of soil

Where one erosion form continuously evolves into another(such as when a rill becomes a gully) record the predominant form.

BID-259 Enter the code that best describes the predominant type of soil that was moved, but did not reach the water body nor to within the bankfull width of the channel by the delivery system identified in question BI199.21.

1. Organic material
2. Clay (forms ribbon 1 inch or longer)
3. Silt / loam (feels smooth but will not form ribbon)
4. Sandy (feels gritty)
5. Gravel (0.8 – 2.5 inches)
6. Cobble & larger (> 2.5 in)

When in doubt, sandy loams or clay loams should be recorded as sand or clay as these components are more critical than loam in determining erosion or percolation rates.

BID-260 Can sedimentation be expected to occur during the next storm event based on your answers to questions.

1. Yes.
2. No.
3. Unknown.

BID-261 Were principles / practices applied?

1. Yes.
2. No.

BID-262 Were measures employed that were over and above the requirements of the plan and/or Rules?

1. Yes.
2. No.

BID-263 Enter the code that best describes the specific cause of soil movement on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

1. Inappropriate timing of the operation with respect to soil and weather conditions
2. Inappropriate location or design.
3. Incorrect maintenance.
4. No or inadequate maintenance.
5. Failure to add reinforcements.
6. Inappropriate log landing location or harvesting activities.
7. Human activities or natural events unrelated to timber harvesting.
8. Erosion from public roads.
9. Activities related to timber operations, unrelated to crossing installation or maintenance.
10. Principles and practices inadequately or incompletely applied.
11. All feasible and reasonable measures were employed, but soil still moved.

Read all of the answers and eliminate the answers that do not apply to arrive at the answer that best describes the situation.

After answering question proceed directly to question O-265

<u>Soil stabilized</u> on the water drafting approach in Approach Area B-Inside the WLPZ/ELZ

BID-264 Were principles / practices applied?

1. Yes.
2. No.

After answering, go to O-265

Overall Crossing and Approaches Evaluation

O-265 Enter the code indicating the approximate volume of sediment delivered to the watercourse based on volume of voids and/or measurable sediment deposits observed at the crossing and approaches.

1. No observed sediment.
2. Trace to 1 cubic yard
3. 1-10 cubic yards
4. 11-50 cubic yards
5. 51-100 cubic yards
6. 101-500 cubic yards
7. 501-1000 cubic yards
8. Greater than 1000 cubic yards

After answering, go to O-266

Overall Subjective Crossing and Approaches Evaluations

O-266 Enter the appropriate rating for the crossing, utilizing the matrix provided below.

	Performing properly, no sign. sediment delivery problems	Performing properly, sediment is still being delivered	Performing properly, no sediment delivery, but there is potential	Not performing properly, sign. sediment delivery problems
Properly designed and constructed	1	2	3	4
Properly designed, not properly constructed	5	6	7	8
Not properly designed, constructed to design	9	10	11	12

O-267 Enter the appropriate rating for Approach A, utilizing the matrix provided below.

	Performing properly, no sign. sediment delivery problems	Performing properly, sediment is still being delivered	Performing properly, no sediment delivery, but there is potential	Not performing properly, sign. sediment delivery problems
Properly designed and constructed	1	2	3	4
Properly designed, not properly constructed	5	6	7	8
Not properly designed, constructed to design	9	10	11	12

O-268 Enter the appropriate rating for Approach B, utilizing the matrix provided below.

	Performing properly, no sign. sediment delivery problems	Performing properly, sediment is still being delivered	Performing properly, no sediment delivery, but there is potential	Not performing properly, sign. sediment delivery problems
Properly designed and constructed	1	2	3	4
Properly designed, not properly constructed	5	6	7	8
Not properly designed, constructed to design	9	10	11	12

O-269 Based on team consensus, what is the overall letter grade (i.e. A, B, C, D, and F) assigned for the approaches.

O-270 Based on team consensus, what is the overall letter grade (i.e. A, B, C, D, and F) assigned for the crossing?

END