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III.C. Road Management

III.C.1. Sediment

III.C.1.a. General Effects

There are at least three provisions in the IFP road management measures that will reduce delivered sediment from existing roads:

- Installation of drivable drain dips and/or ditch relief pipes at the nearest practicable location to streams with an adequate filtration zone in order to minimize sediment delivery to streams.
- Installation of road drainage features located such that road runoff distances generally do not exceed 300 feet (and will not exceed 400 feet) along the road centerline; on erodible soil types, or on road grades steeper than 8 percent, this spacing will be reduced.
- When the outlet of road drainage features are too close to streams for effective forest-floor filtration, supplemental sediment filtration will be provided (such as slash filter windrows, straw-bales, silt fences, etc.) and/or drainage feature spacing will be decreased to minimize sediment delivery.

The effect of these three measures on delivered sediment from existing and potential new roads was examined based on data collected in the Clearwater River basin by Western Watershed Analysts (WWA) for the IDEQ in 2000 and in 2005 for the nine FAA watersheds.

In the IDEQ study (WWA 2000) total road system sediment production given the road system built and maintained to current FPA standards (the existing condition) was calculated and then compared to sediment production with implementation of the IFP road management measures.

WWA performed road sediment analyses for nine watersheds for the Idaho Department of Environmental Quality (IDEQ) in 2000 using the Washington watershed analysis road sediment and delivery assessment procedures. These nine watersheds were selected to provide a representative range of the major geology types found in the Clearwater River basin. These included granitics, basalts, alluviums, gneisses and schists, and ranged in relative erodibility from very high (alluviums and some granitics) to low (basalts). Total delivered road sediment ranged from 1.2 to 25.6 tons per year per mile of road and averaged 10.6 tons per year per mile across all nine watersheds. Road mileage representative of state and private lands in the Clearwater River basin averages 4.7 miles per square mile of watershed area.¹ Combining these two averages yields an average of approximately 49.8 tons of sediment delivered per year per square mile

¹ Data derived from Potlatch Corporation's GIS database, with 10,860 miles of road on 2,290 square miles of Potlatch Corporation's operating area in the Clearwater River basin.

of watershed area (10.6 tons per year per mile x 4.7 miles per square mile) from existing roads in the Clearwater River basin. Developed forested area in the Salmon River basin is much smaller than in the Clearwater River basin, but it is reasonable to assume that road density of commercial forestlands is similar, given that similar logging and road system technologies are applied in these areas.

Again according to data from Potlatch Corporation, new road construction on private lands in the Clearwater region is expected to be approximately 0.02 miles per square mile of watershed area per year in the near future. Assuming that under the current FPA rules these new roads would be constructed to a standard similar to the existing road system, this would contribute an additional 0.21 tons of sediment per square mile of watershed area every year (0.02 miles per square mile x 10.6 tons per year per mile). At the same time, it is expected that approximately 0.02 miles of road per square mile of watershed area per year will be abandoned in the near future, effectively offsetting the sediment generated from new roads constructed in the same time period. Assuming the same rate of construction and abandonment over the next 30 years, under the status quo, roads would be contributing the same 49.8 tons per year per square mile at the end of the 30-year period.

In order to estimate the road sediment reduction due to just one of the IFP road management measures (placing culverts optimally near stream crossings), additional sediment modeling calculations were completed using certain assumptions about the road systems and the way in which the road management measures would be implemented. Road drainage analysis work done by WWA for previous projects (assuming typical road or stream crossing conditions and road geometry) suggests that optimal culvert placement to minimize combined direct and indirect delivery near stream crossings occurs when the first culvert nearest the stream crossing is located approximately 75 to 80 feet from the stream crossing. WWA used this result in road drainage analysis done for Plum Creek Timber Company in connection with their Native Fish HCP (McGreer et al. 1998), in which it was assumed that at stream crossings the first drainage structure would be placed approximately 80 feet from the stream. Also based on that same work for Plum Creek Timber Company, WWA assumed that two-thirds of all stream crossings are one-sided (road climbs continuously through crossing) and one-third of stream crossings are two-sided (road dips down into stream crossing from both sides). These assumptions result in an average direct delivery at stream crossings of 110 feet ($0.6 \times 80 \text{ feet} + 0.3 \times 2 \times 80 \text{ feet}$). Therefore, WWA ran the modeling for all nine Clearwater River basin watersheds again with the following modifications:

- Any stream crossings with more than 110 feet of contributing length were reduced to 110 feet equivalent direct contributing length
- Any stream crossings with less than 110 feet of contributing length were left unchanged

- Any sediment contributed indirectly from stream-adjacent roads was left unchanged
- All road parameters (e.g., surfacing, traffic level, etc.) remained the same as in the original analysis

The remodeling showed that reducing the average direct delivery length to 110 feet in the nine watersheds in the Clearwater River basin resulted in a reduction of 34 percent (from 10.6 to 6.9 tons per year per mile) in delivered sediment from existing roads averaged across all nine watersheds. This compares closely with the average sediment delivery reduction of 44 percent for the 11 watersheds examined in WWA's earlier work for Plum Creek Timber Company.

With implementation of the IFP road management measures, all existing roads would be upgraded within 15 years. Therefore, after 15 years with the IFP road management measures, existing roads would be contributing a total of 32.4 tons of sediment per year per square mile of watershed area (6.9 tons per year per mile x 4.7 miles per square mile), which would remain constant for the remaining 15 years, for an average of 36.8 tons per year per square mile over the 30-year period.

New roads built to the IFP road management measures standards would, on average, also contribute only 6.9 tons per year per mile. At a rate of new construction of 0.02 miles per square mile per year, new roads would contribute an additional 0.14 tons of sediment per square mile of watershed area every year (0.02 miles per square mile x 6.9 tons per year per mile). After 30 years with the IFP road management measures, new roads would be contributing a total of 4.2 tons per year per square mile (30 x 0.14 tons per year per square mile), or an average of 2.1 tons per year per square mile (average of 0 and 4.2 tons per year per square mile) over the 30-year period.

At the same time, approximately 0.02 miles of road per square mile of watershed area will be abandoned every year, but these will be old roads that would have been contributing 10.6 tons per year per mile. Therefore, abandoning old roads will reduce sediment by 0.21 tons per square mile of watershed per year (0.02 miles per square mile x 10.6 tons per year per mile), for a reduction of 6.3 tons per year per square mile (30 x 0.21 tons per year per square mile) after 30 years, or an average of 3.2 tons per year per square mile over the 30-year period. This results in a total road sediment contribution from new and existing roads under the IFP road management measures of 35.7 tons per year per square mile of watershed area (36.8 + 2.1 - 3.2 tons per year per square mile) averaged over the 30-year period, or a net reduction of 28 percent ((49.8 - 35.7) / 49.8) due to implementation of just one of the road management measures (placing culverts approximately 80 feet from stream crossings).

Although the effects of other IFP road management measures (specifically, 300 to 400 foot drain spacing, and drain outlet filtration) are more difficult to quantify, they will certainly reduce road sediment delivery to streams by some additional amount. For example, filter windrows at the toe of fill slopes reduce road sediment delivery to adjacent streams by an average of 87 percent (Burroughs and King 1985).

Therefore, the estimate of a 28 percent reduction in delivered road sediment derived above is conservative, and the actual reduction due to the IFP road management measures will most certainly be greater than 28 percent.

III.C.1.b. Specific Localized Effects (FAA)

Western Watershed Analysts performed road sediment analyses for the nine FAA watersheds in 2005 using both the Washington Road Sediment Erosion Model (WARSEM) and Forest Service Water Erosion Prediction Project (WEPP) assessment procedures. All road-stream crossings accessible by four-wheeler were surveyed in all nine watersheds,² and all data necessary for input to the models was gathered in the field during the summer of 2005. Current road sediment contribution to streams was then estimated using these inputs in both of the models.

IDL supervisory areas were consulted regarding future harvest plans in each of the FAAs to estimate where and when new roads would likely be built or old roads abandoned. It was also assumed that by year 10 of the IFP, at least half of the stream crossings requiring improvements would be upgraded according to IFP measures (e.g., additional relief drains, rock surfacing, etc.), and that the remaining crossings would be upgraded by year 15 of the IFP. Both models were then run again for the resulting road conditions after 10, 20, and 30 years. The results are illustrated in Figures III.C-2 and III.C-3.

² Although it is true that some potential stream crossings were not accessible by four-wheeler, sediment contributions from crossings on these abandoned and/or overgrown roads would be miniscule in comparison to those from active open roads.

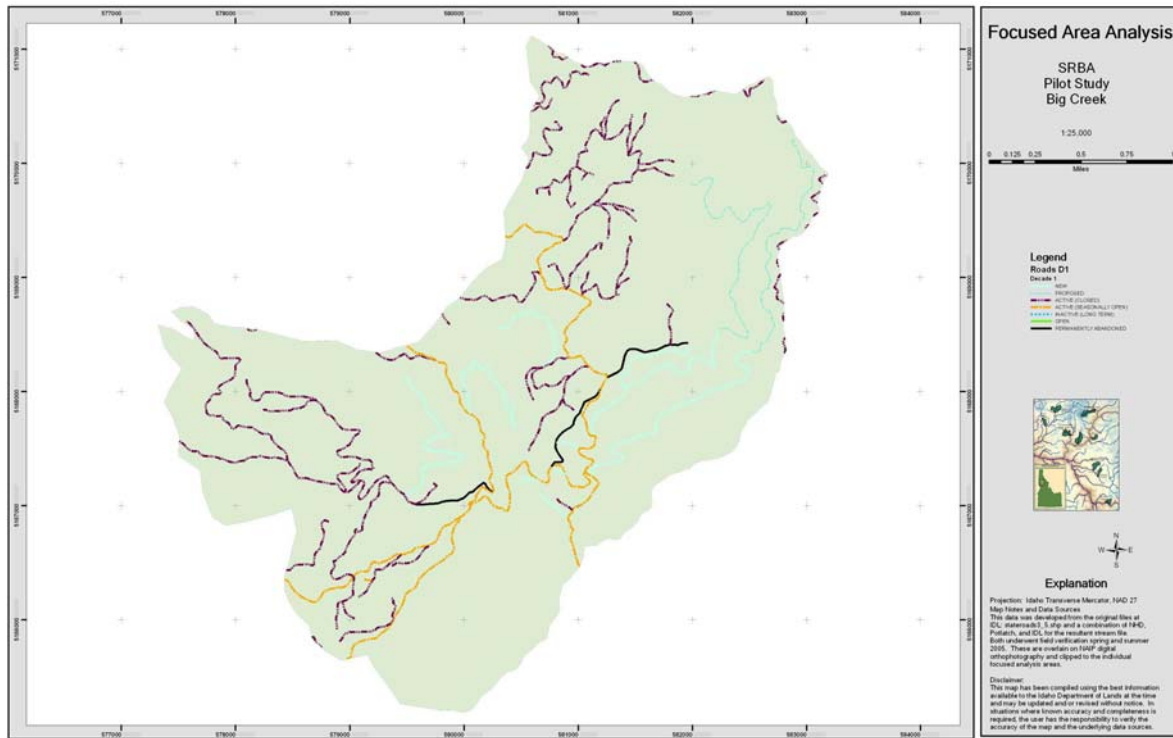


Figure III.C-1 Example of GIS road map for an FAA

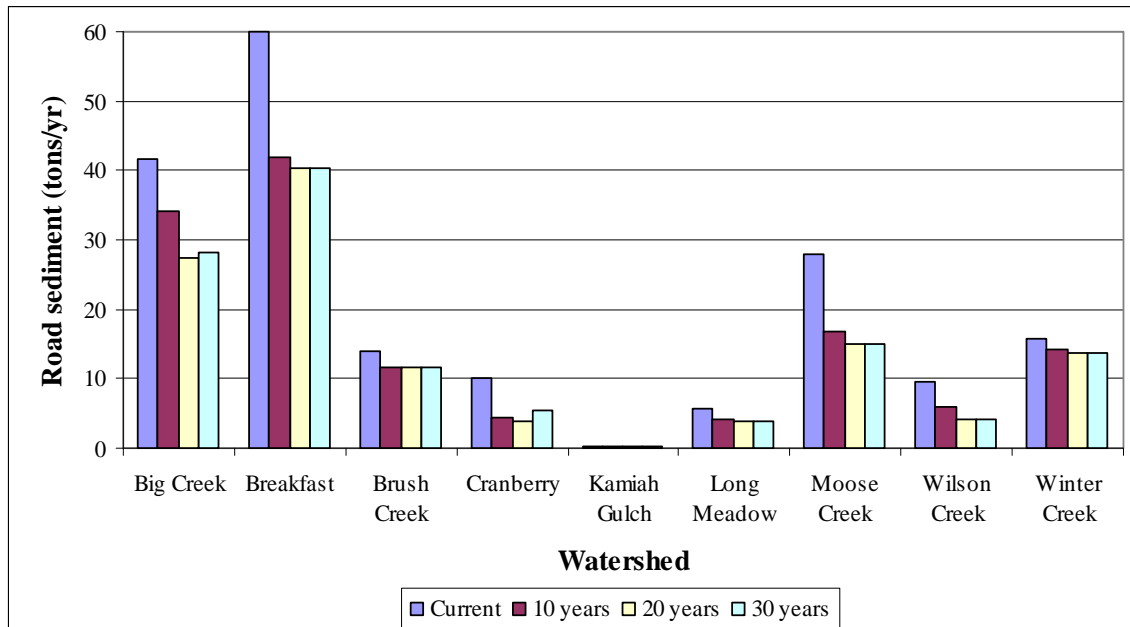


Figure III.C-2 WARSEM road sediment modeling results in FAAs

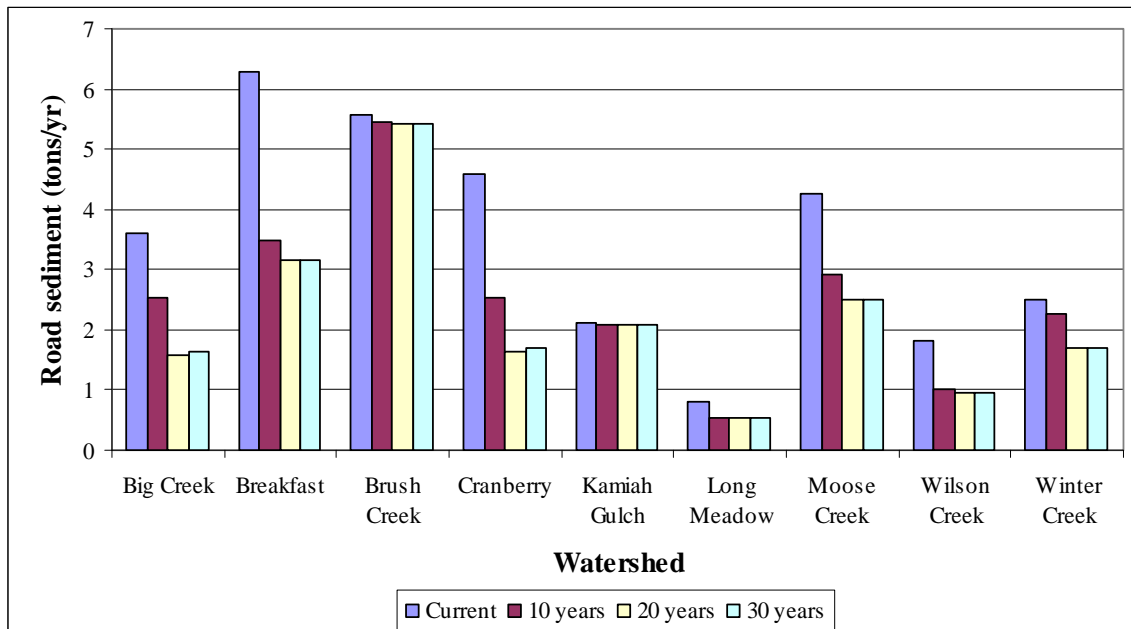


Figure III.C-3 WEPP road sediment modeling results in FAAs

Easily observed from the figures is the fact that WEPP consistently estimates substantially lower road sediment delivery rates than WARSEM; WWA has consistently found this difference in every case where we have applied both models. However, despite the discrepancy in absolute road sediment delivery rates, very similar trends due to implementation of the IFP are evident from both models. Reductions in delivered road sediment over 30 years predicted from the WEPP model range from 1 percent to 63 percent, averaging 36 percent; reductions predicted from WARSEM range from 3 percent to 57 percent, averaging 31 percent (see Table III.C-1).

Table III.C-1 WARSEM road sediment comparisons to natural background rates of watershed erosion in FAAs and reductions over 30 years of the IFP

| Watershed | Current road sediment (tons/yr) | Natural background (tons/yr) | Current increase over background (%) | Road sediment in 30 years (tons/yr) | Reduction in 30 years (%) |
|------------------|--|-------------------------------------|---|--|----------------------------------|
| Big Creek | 41.5 | 183.6 | 23 | 28.1 | 32 |
| Breakfast Cr. | 59.9 | 305.4 | 20 | 40.5 | 32 |
| Brush Creek | 14.0 | 204.7 | 7 | 11.6 | 17 |
| Cranberry Cr. | 10.1 | 246.5 | 4 | 5.5 | 45 |
| Kamiah Gulch | 0.3 | 83.9 | 0 | 0.3 | 3 |
| Long Meadow | 5.6 | 280.3 | 2 | 3.8 | 32 |
| Moose Creek | 28.0 | 334.0 | 8 | 15.0 | 46 |
| Wilson Creek | 9.5 | 115.5 | 8 | 4.1 | 57 |
| Winter Creek | 15.7 | 283.8 | 6 | 13.6 | 13 |

For comparison purposes, the Washington analysis procedure incorporates a method for estimating the natural background rate of erosion for a watershed. The results of these computations for the nine FAA watersheds are also shown in Table III.C-1. Washington procedures suggest that in watersheds where the increase over natural is less than 50 percent, effects from road sediment are likely not detectable, and there is minimal hazard due to road sediment delivery to streams (WFPB 1997). In all nine FAA watersheds, the increase factor currently is well under 50 percent (highest is in Big Creek, with 23 percent), suggesting that road sediment is not currently a chronic problem in any of these watersheds. Furthermore, implementation of the IFP is estimated to reduce road sediment delivery to streams by an average of approximately 31 percent.

III.C.2. Unstable Slopes

III.C.2.a. General Effects

A number of IFP road management measures are designed to minimize the risk of slope instability associated with roads:

- An attempt will be made to find a suitable alternative location for new roads that are proposed on side slopes greater than 60 percent and/or in unstable or erodible soils, defined as high in the Idaho CWE process or other agreed upon hazard-rating analysis process; where an alternative location is not feasible, the road will be full benched without fill slope disposal.

- Stream crossing culvert installations will be designed to accommodate at least the 50-year peak flood.
- Seeps or springs will be avoided during road design and construction, if possible; if roads cross seeps or springs, drainage features will be installed that pass accumulated surface water across the road prism and returns it to the forest floor as close to the point of origin as reasonably practicable.

The literature demonstrates that the majority of mass wasting associated with roads is from fill and sidecast failures that develop into debris avalanches on steep slopes (Bush et al. 1997; Fiksdal 1974; Gonsior and Gardner 1971; Gray and Megahan 1981; Jones et al. 2000; McClelland et al. 1997; Megahan et al. 1978; Sidle et al. 1985; Skaugset et al. 1996; and Swanson and Dyrness 1975). In the Clearwater National Forest of Idaho, McClelland et al. (1997) reported that most road failures following 1995 and 1996 flood events³ were fill failures on steep slopes and were generally associated with poor construction, maintenance, and/or drainage practices. Specifically, McClelland et al. (1997) found that of the road related failures, 75 percent were fill slope failures, and that of all the failures recorded in the study, 58 percent originated from hillslopes of 56 percent or greater (greater than 56 percent was the highest hillslope category defined in the study).

Consistent with the studies noted above, WWA performed a landslide assessment of the Papoose Creek watershed, a tributary of the Lochsa River, for Plum Creek Timber Company in 2001 (McGreer and Schult 2001). This study was a management commitment required by the terms of Plum Creek Timber Company's Native Fish Habitat Conservation Plan. Of the 65 failures documented by this Papoose Creek study, 41 were related to roads (63 percent of the total), and of those 41 road-associated failures, 18 were on slopes of 60 percent or greater (44 percent of road-related failures). Because virtually all Plum Creek Timber Company's lands in the watershed have been subject to one or more logging entries, no attempt was made to differentiate between natural and harvest-associated landslides in the watershed.

In virtually all of the studies reviewed for this report, the majority of the landslides observed were from roads built years ago in locations and with construction methods that have since become outdated and inferior. As practices have improved, and as old roads eventually stabilize, the failure risk has decreased; as early as 1984, Ice (1984) noted evidence from west side studies that rates of road failure were decreasing. In a summary of impacts of the 1996 floods in Oregon, Robison et al. (1999) reported

³ 1995 and 1996 events were three high intensity rain storms in the fall of 1995 and spring 1996 following snowpack accumulation averaging 200 percent of normal and producing 30 to 50-year flood/landslide events (Falter and Rabe 1997 page ix).

“current road management practices are reducing the size of road associated landslides, as well as the number of landslides.” McClelland et al. (1997) also reported that the rate of failure of roads built in the 1970s through the 1990s following intense rain-on-snow precipitation during the 1995 and 1996 floods was approximately one half the rate for roads built in the 1950s and 1960s.

In a companion study to McClelland et al. (1997), Falter and Rabe (1997) assessed the consequences of the 1995 and 1996 floods and landslide events on stream channels. Thirty-five stream reaches were studied, some of which received landslide-driven sediment (flood/landslide channels) and some of which received only flood flows but received no landslide sediment (flood-only channels). Effects on channels in roaded versus unroaded watersheds were also assessed, and pre-event to post-event comparisons were provided for a subset of the streams studied where pre-event data were available. This study is particularly relevant to interpretation of likely effects of landslides on stream channels and aquatic habitat, and to response of channels in managed versus unmanaged watersheds. Falter and Rabe (1997) also reference several other landslide impact studies as they discuss their results, noting, however, that there had been little documentation on the effects of flooding in conjunction with mass wasting (i.e., flood-only effects versus flood and landslide effects) - a particularly illuminating comparison for understanding potential effects of management in roaded watersheds.

In the Discussion and Conclusions sections of their report, Falter and Rabe (1997) state that severity of impacts from the 1995 to 1996 flood and landslide sequence were variable, with dramatic impacts in some streams and relatively few changes in others. They note that some of the changes, such as scour from debris torrents, loss of LWD, and decreased channel stability, negatively impacted fish habitat. Other changes, such as import of LWD, deposition of gravel, and improvement in channel complexity were generally considered to be positive and that “since different streams reacted in different ways, it is impossible to make a general assessment stating overall impacts on stream habitat as either negative or positive.”

Falter and Rabe (1997) also report that impacts sustained by flood-only streams were often found to be similar to impacts sustained by flood and landslide streams; in-stream habitat quality and quantity significantly declined from pre-event conditions in both groups with respect to stream width, width:depth, percent embeddedness, and acting LWD. However, biological conditions as indicated by various biological indices were generally more negatively impacted in flood and landslide streams than in flood-only streams. These findings are particularly important given the finding by McClelland et al. (1997) wherein roads generally have increased landslide rates, and by inference, stream channels in roaded

watersheds are more likely to be impacted by landslides. However, Falter and Rabe's (1997) analysis of effects in roaded versus unroaded watersheds were inconclusive:

As noted in previous comparisons, the group of streams with the greater stream power (unroaded) were little impacted through the flood/landslide sequence of 1995/96. Unroaded streams were significantly deeper, had significantly lower width:depth ratios, yet had significantly less stable channels/banks. Although the absence of roads may be considered to be the key component influencing the comparison, greater stream power in those streams is more likely the causative factor.

IFP road management measures call for avoiding construction of new roads on slopes greater than 60 percent or in unstable soils, or if not avoidable, utilizing full bench construction. Moreover, perched fills and other indicators of high road-associated landslide hazards on existing roads must be addressed on lands enrolled to the IFP as "hot spots." Although it is the exact effectiveness of these IFP measures is uncertain and cannot be accurately predicted, construction of new roads according to IFP requirements, and attention to existing roads through improved drainage and hot spot repair, may be expected to reduce future rates of landslide occurrence by approximately 50 percent; this is an improvement similar in order of magnitude to the decrease in rate of failure of roads built in the 1970s through the 1990s compared to the rate for roads built in the 1950s and 1960s that also was likely due to improved road location and construction practices (McClelland et al. 1997).

Insufficient stream crossing culvert capacity, often compounded by debris obstruction, has been noted as an important cause of culvert failure, resulting in overtopping or diversion from streambeds and onto unstable road fills, with associated mass wasting and severe gully erosion (Furniss et al. 1991; McClelland et al. 1997). Many existing roads were built when culvert design requirements were based on the 10 to 25-year event, but the current forest practices rules for Idaho (as well as the IFP measures) call for stream culvert design capacity based on the 50-year flood event. As a demonstration of the risk associated with culvert design capacity, Figure III.C-4 illustrates the probability that a culvert designed to pass a given flood will be overtopped in 30 years.⁴

⁴ Overtopping means only that the hydraulic capacity of the culvert is exceeded; overtopping does not necessarily mean culvert failure.

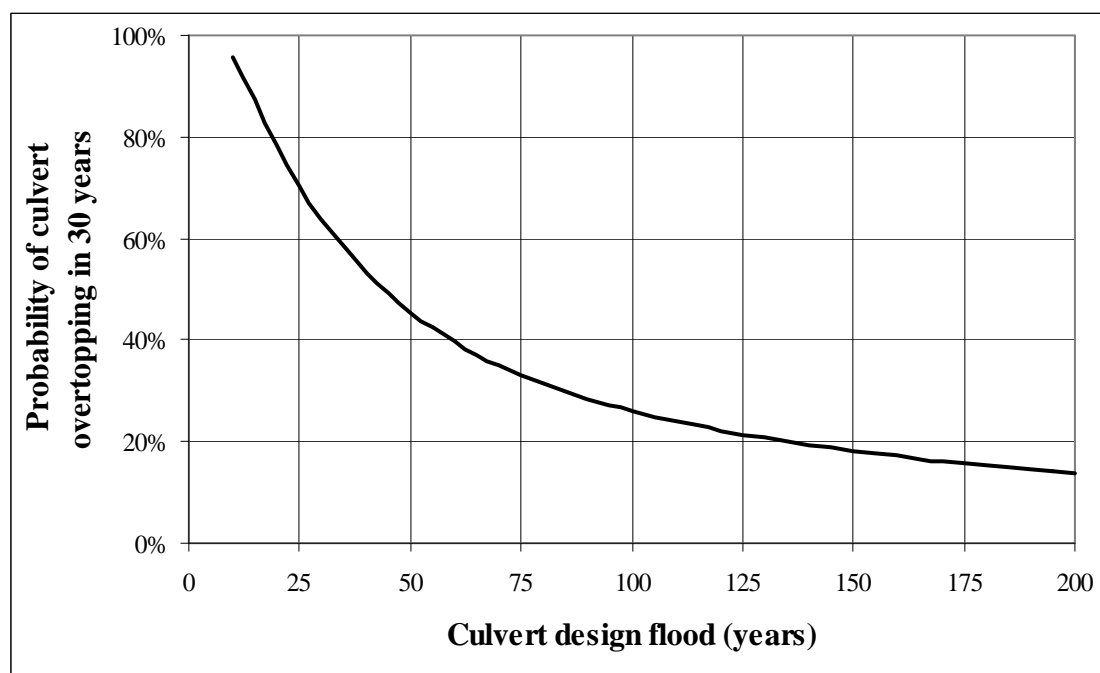


Figure III.C-4 Culvert overtopping probability in 30 years

A culvert designed to pass a 25-year flood has a 71 percent probability of overtopping in 30 years, whereas a culvert designed to pass a 50-year flood has a 45 percent probability of overtopping in 30 years, and a culvert designed to pass a 100-year flood has a 26 percent probability of overtopping in 30 years. In other words, going from a 25-year design to a 50-year design reduces the probability of overtopping by about one third, and going from a 50-year design to a 100-year design reduces the probability of overtopping by almost one half. The choice depends entirely on the desired design life and the probability of overtopping that is deemed acceptable.⁵ Furthermore, culverts only come in certain sizes, and during road construction, the size of pipe required to pass more than the design flow is always used. Therefore, in practice, culverts are sized to pass the 50-year flood minimum, meaning that they are always sized for something larger than the 50-year flood.

The practical implication of culvert sizing versus failure risk is illustrated by a culvert risk assessment done by Western Watershed Analysts for the Papoose Creek watershed (WWA 2001). This survey identified only one failed stream crossing culvert out of 29 culverts surveyed on Plum Creek Timber Company's lands (the one culvert failure was due to a debris flow that initiated approximately 1,000 feet upslope on National Forest land) despite the fact that many of these culverts had been in place for decades

⁵ Idaho and Oregon Forest Practices Act rules currently require a minimum 50-year flood design; Montana requires a minimum 25-year flood design; Washington requires a minimum 100-year design.

and survived the severe floods of 1995, 1996 (30 to 50-year events) and 1997. This low crossing failure rate was attributed in part to the fact that most culverts had been installed with a size that would accommodate at least the 50-year flood (25 of 29 culverts surveyed). Similar surveys could be conducted as part of the IFP adaptive management efforts designed to determine if impacts of IFP implementation are similar to current expectations.

In summary of the effects of IFP road management measures, the literature demonstrates that avoidance of hazardous locations and attention to road fills and drainage are the best means of preventing road failures and sediment delivery. The IFP measures were designed with these very considerations in mind, and therefore can be expected to reduce both the rate and the impacts of road associated hillslope failures in comparison to current Idaho forest practice rules.

III.C.2.b. Specific Localized Effects (FAA)

Characteristics of landslides for the nine FAA watersheds that occurred as a result of the 1995 and 1996 flood events were recorded as part of the inventory conducted by McClelland et al. (1997). Total number of landslides and landslide volume and number of road-associated landslides and total road-associated landslide volume delivered to streams are shown for each of the FAA watersheds in Table III.C-2.

Harvest versus “natural” numbers and volumes are not separated in these data since nearly all lands in the FAA watersheds have been harvested relatively recently (i.e., within the past 50 years). Locations of landslides are shown in Figure III.C-5 for the Breakfast Creek watershed (the FAA watershed with the highest density of landslides) as an example of where landslides are located in the watershed and in relation to the CWE mass wasting hazard mapping for this watershed.

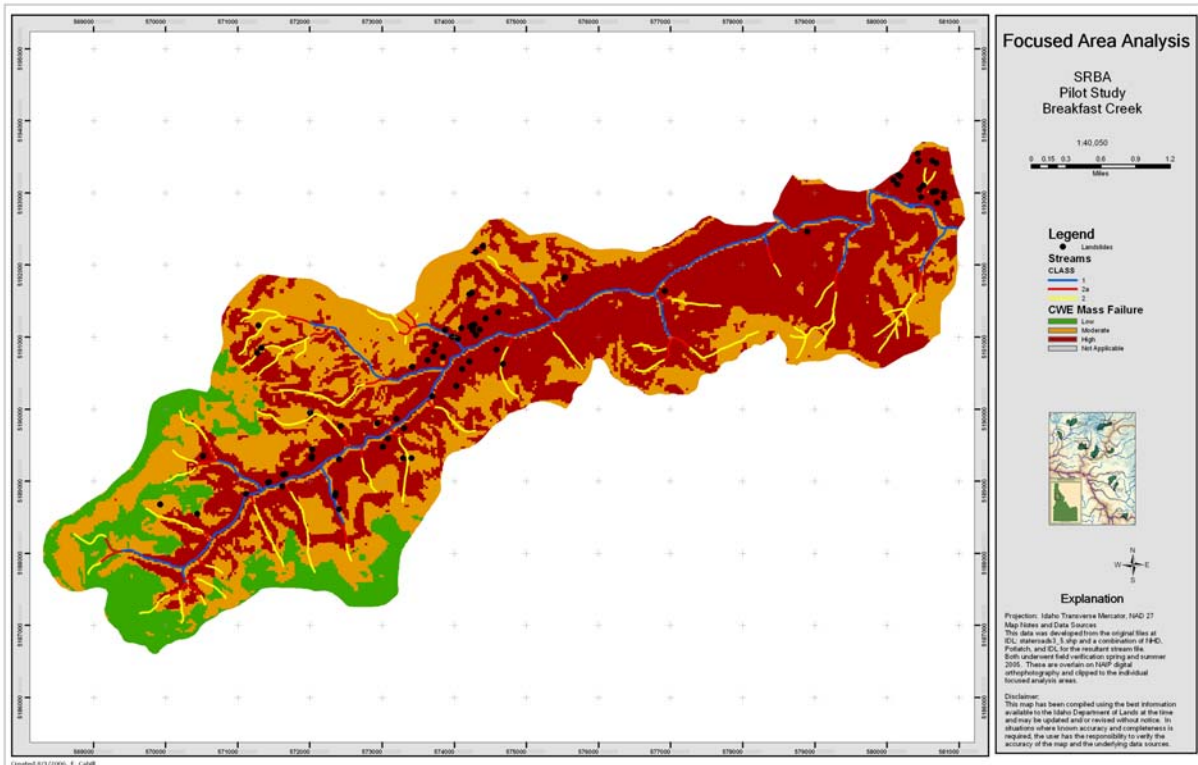


Figure III.C-5 Landslides within the Breakfast Creek associated with the 1995 to 1996 floods and CWE mass wasting hazard mapping.

Table III.C-2 Landslides in FAA watersheds associated with the 1995 to 1996 floods

| Watershed | All Landslides | | | Road-related Landslides Only | | |
|---------------|----------------|---------------------------|-------------------------------------|------------------------------|---------------------------|-------------------------------------|
| | # slides | Volume (yd ³) | Delivered volume (yd ³) | # slides | Volume (yd ³) | Delivered volume (yd ³) |
| Big Creek | 1 | 475 | 158 | 0 | 0 | 0 |
| Breakfast Cr. | 77 | 14,270 | 5,125 | 65 | 12,145 | 4,618 |
| Brush Creek | 0 | 0 | 0 | 0 | 0 | 0 |
| Cranberry Cr. | 4 | 355 | 73 | 2 | 220 | 73 |
| Kamiah Gulch | 0 | 0 | 0 | 0 | 0 | 0 |
| Long Meadow | 22 | 5,635 | 2,720 | 14 | 3,580 | 1,577 |
| Moose Creek | 2 | 950 | 317 | 2 | 950 | 317 |
| Wilson Creek | 6 | 770 | 98 | 4 | 270 | 98 |
| Winter Creek | 0 | 0 | 0 | 0 | 0 | 0 |

Ideally, the landslide information of Table III.C-2 would be converted to provide an annual sediment delivery rate expressed in tons per year in order to allow comparison to some estimate of natural rate of landsliding in these watersheds. However, this is not possible, because the landslide volumes of Table III.C-2 are volumes associated with a specific point in time (e.g., associated with the 1995 to 1996

floods), and therefore do not represent average annual rates. Moreover, natural rates of landsliding are unknown for these watersheds. Nevertheless, it is reasonable to assume that many, and perhaps nearly all, road-associated landslides in these watersheds would not have occurred had the roads not been constructed, and their impact on streams may best be considered as point-in-time impacts.

Seventy-nine percent of the delivered landslide volume in the FAA watersheds is road-related. As discussed earlier, landslide rates from roads constructed per IFP requirements, plus attention to existing roads through improved drainage and hot spot repair, may be expected to reduce future rates of road-related landslide occurrence on the order of 50 percent. Actual rates of landslide occurrence in the FAA watersheds, or via a more geographically widespread inventory, could be tracked and evaluated as part of the IFP adaptive management strategy. Effects on select instream habitat factors (e.g., cobble embeddedness, pool area, etc.) could also be tracked in both landslide-affected and none-affected streams, similar to the study conducted by Falter and Rabe (1997).

Hydraulic design capacity and/or numbers of culvert failures that may have occurred through time were not surveyed for the FAA watersheds, with the exception of Cranberry Creek, and a second watershed (Pete and Charlie Creek) not included in the FAAs. The IFPA rules require determination of 50-year design capacity through use of engineering methods acceptable to the Department or through application of a design size default table provided in the rules. Applying the IFPA default table for Cranberry Creek, 10 of the 16 stream crossing culverts in the watershed are smaller than needed to pass the 50-year design flow; all 6 stream crossing culverts in Pete and Charlie Creek are smaller than needed to pass the 50-year flow.

Nearly all of the culverts in the Cranberry Creek and Pete and Charlie Creek watersheds were installed many years ago, prior to 1990, when design requirements were for either the 25-year flood, or for watershed areas less than 10 square miles (e.g., nearly all situations where culverts would have been used) a 10-year design, yet they have survived through major flood events like the 1995 and 1996 floods of 30 to 50-year magnitude. Existing culvert design capacity, fish passage evaluations, culvert replacement, and culvert failures can all be tracked and evaluated as needed as part of the IFP adaptive management strategy.

III.C.3. Hydrologic Connectivity

III.C.3.a. General Effects

As described in the baseline conditions, roads can potentially increase peak streamflows by replacing subsurface flow paths with surface flow paths through capture of subsurface water in road cuts and by reducing the rate of infiltration into compacted surfaces, thereby generating excess surface flows (Coe 2004). Although it has been hypothesized that increases in peak flows from roads may be due to increases in “drainage density” stemming from connectivity between the road system and the stream network at channel crossings and through gullies below relief drains (Montgomery 1994; Wemple et al. 1996; and Jones et al. 2000), road mileage that drains to streams is not the same as an increase in the length of streams in the watershed (Jones et al. 2000). Nonetheless, the following provides an analysis of IFP effects on road-stream connectivity.

At least two IFP road management measures designed to reduce delivered sediment from roads will also limit road-stream connectivity:

- Installation of drivable drain dips and/or ditch relief pipes at the nearest practicable location to streams with an adequate filtration zone in order to minimize sediment delivery to streams.
- Installation of road drainage features located such that road runoff distances generally do not exceed 300 feet (and will not exceed 400 feet) along the road centerline; on erodible soil types, or on road grades steeper than 8 percent, this spacing will be reduced.

Analysis was performed to evaluate the effect of these measures on the length of road that is hydrologically connected to the stream system. The total road length connected to the stream system was examined, given the road system built and maintained to current FPA standards (the existing condition), and with implementation of the IFP measures.

For the nine watersheds in the Clearwater River basin that were examined for the Idaho Department of Environmental Quality (IDEQ) in 2000, Western Watershed Analysts found that road length hydrologically connected to the stream system ranged from 24 percent to 65 percent of the road length surveyed and averaged 41 percent across all nine watersheds (WWA 2000). Road mileage representative of state and private lands in the Clearwater River basin averages 4.7 miles per square mile of watershed area.⁶ Combining these two averages yields an average of approximately 1.93 miles of existing road hydrologically connected to the stream system per square mile of watershed area (0.41 x 4.7 miles per square mile) in the Clearwater River basin.

⁶ Data derived from Potlatch Corporation’s GIS database, with 10,860 miles of road on 2,290 square miles of Potlatch Corporation’s operating area in the Clearwater River basin.

According to data from Potlatch Corporation, new road construction on private lands in the Clearwater region is expected to be approximately 0.02 miles per square mile of watershed area per year in the near future. Assuming that under the current FPA rules these new roads would be constructed to a standard similar to the existing road system, 41 percent of this road mileage would be hydrologically connected to the stream system. At the same time, it is expected that approximately 0.02 miles of road per square mile of watershed area per year will be abandoned in the near future, effectively offsetting the new road construction in the same time period. Assuming the same rate of construction and abandonment over the next 30 years, under the status quo, the same 1.93 miles of road would be hydrologically connected to the stream system per square mile at the end of the 30-year period.

In order to estimate the reduction in road length hydrologically connected to the stream system due to just one of the IFP road management measures (placing culverts optimally near stream crossings), WWA did additional calculations using certain assumptions about the road systems and the way in which the measures would be implemented. Road drainage analysis work done by WWA on previous projects (assuming typical road/stream crossing conditions and road geometry) suggests that optimal culvert placement to minimize sediment delivery near stream crossings occurs when the first culvert nearest the stream crossing is located approximately 75 to 80 feet from the stream crossing. WWA used this result in road drainage analysis done for Plum Creek Timber Company in connection with their Native Fish HCP (McGreer et al. 1998), in which it was assumed that at stream crossings the first drainage structure would be placed approximately 80 feet from the stream. Also based on that same work for Plum Creek Timber Company, WWA assumed that two-thirds of all stream crossings are one-sided (road climbs continuously through crossing) and one-third of stream crossings are two-sided (road dips down into stream crossing from both sides). These assumptions result in an average direct contributing length at stream crossings of 110 feet ($0.6 \times 80 \text{ feet} + 0.3 \times 2 \times 80 \text{ feet}$). Therefore, WWA ran the modeling for all nine Clearwater watersheds again with the following modifications:

- Any stream crossings with more than 110 feet of contributing length were reduced to 110 feet equivalent direct contributing length
- Any stream crossings with less than 110 feet of contributing length were left unchanged
- Any indirect contributing length from stream-adjacent roads was left unchanged

The remodeling showed that reducing the average direct delivery length to 110 feet in the nine watersheds in the Clearwater River basin resulted in a reduction of 23 percent (from 41 percent to 31 percent) in total existing road length that is hydrologically connected to the stream system averaged across all nine watersheds.

Under the IFP road management measures, all existing roads would be upgraded within 15 years. Therefore, after 15 years, under the IFP, 1.46 miles of existing road length would be hydrologically connected to the stream system per square mile of watershed area (0.31×4.7 miles per square mile), which would remain constant for the remaining 15 years, for an average of 1.58 miles per square mile over the 30-year period.

Assuming that new roads built under the IFP are also built to the new standards, 31 percent of new road length would be hydrologically connected to the stream system. At a rate of new construction of 0.02 miles per square mile per year, after 30 years under the IFP, 0.19 miles of new road length would be hydrologically connected to the stream system per square mile of watershed area (0.31×30 years \times 0.02 miles per square mile per year), or an average of 0.09 miles per square mile (average of 0 and 0.19 miles per square mile) over the 30-year period.

At the same time, approximately 0.02 miles of road per square mile of watershed area will be abandoned every year, but these will be old roads with 41 percent hydrologically connected to the stream system. Therefore, abandoning old roads will reduce hydrologic connectivity by 0.25 miles per square mile of watershed (0.41×30 years \times 0.02 miles per square mile per year) after 30 years, or an average of 0.12 miles per square mile over the 30-year period. This results in a total road length hydrologically connected to the stream system under the IFP of 1.55 miles per square mile of watershed area ($1.58 + 0.09 - 0.12$ miles per square mile) averaged over the 30-year period, or a net reduction of 20 percent ($(1.93 - 1.55) / 1.93$) due to implementation of just one of the road management measures (placing culverts approximately 80 feet from stream crossings).

Although the effects of other IFP road management measures (specifically, 300 to 400 foot drain spacing) are more difficult to quantify, they will certainly further reduce the length of road hydrologically connected to the stream system by some additional amount. For example, in the nine watersheds surveyed in the Clearwater River basin for the IDEQ study (WWA 2000), culvert spacing near stream crossings averaged approximately 350 feet, and exceeded 400 feet 26 percent of the time; relief drain spacing averaged almost 1,300 feet. Reducing relief drain spacing to no more than 400 feet will “disconnect” a substantial portion of previously connected road mileage. This disconnection will also reduce the probability of gullies forming below relief drains, both reducing the likelihood that the road length draining to the relief drain will become hydrologically connected to the stream system and also reducing the potential length of road that could become connected (Wemple et al. 1996). Therefore, the estimate of a 20 percent reduction in hydrologically connected road length derived above is conservative,

and the actual reduction due to implementation of IFP road management measures will most certainly be greater than 20 percent.

III.C.3.b. Specific Localized Effects (FAA)

Using the same road-stream crossing inventory conducted for road sediment analyses in 2005, WWA was able to assess the effects of IFP measures on hydrologic connectivity in the nine FAA watersheds.

However, it should be noted that this analysis is not necessarily comparable to results from other studies, because the analysis presented here accounts only for road length connected directly to the stream system via road ditches near stream crossings; it does not consider road lengths connected to streams via gullies or other surface flow paths. Although gullies between roads and streams were rarely observed, the connected length estimates provided below may be artificially low to some extent. The results of this analysis are presented in Table III.C-3 and Figures III.C-5 and III.C-6.

Table III.C-3 Hydrologically connected road length in FAAs

| Watershed | Current connected road length (mi) | Current connected length (mi/mi²) | Current connected length as percentage of stream length (%) | Connected road length in 30 years (mi) | Reduction in 30 years (%) |
|------------------|---|---|--|---|----------------------------------|
| Big Creek | 2.95 | 0.50 | 13.7 | 1.59 | 46 |
| Breakfast Cr. | 2.26 | 0.17 | 6.3 | 1.78 | 21 |
| Brush Creek | 1.82 | 0.30 | 7.6 | 1.55 | 15 |
| Cranberry Cr. | 2.30 | 0.16 | 8.9 | 1.22 | 47 |
| Kamiah Gulch | 1.25 | 0.27 | 14.2 | 0.96 | 23 |
| Long Meadow | 1.35 | 0.12 | 4.6 | 1.35 | 0 |
| Moose Creek | 3.28 | 0.25 | 9.4 | 1.82 | 45 |
| Wilson Creek | 0.68 | 0.11 | 5.0 | 0.46 | 32 |
| Winter Creek | 4.33 | 0.37 | 14.6 | 3.36 | 22 |

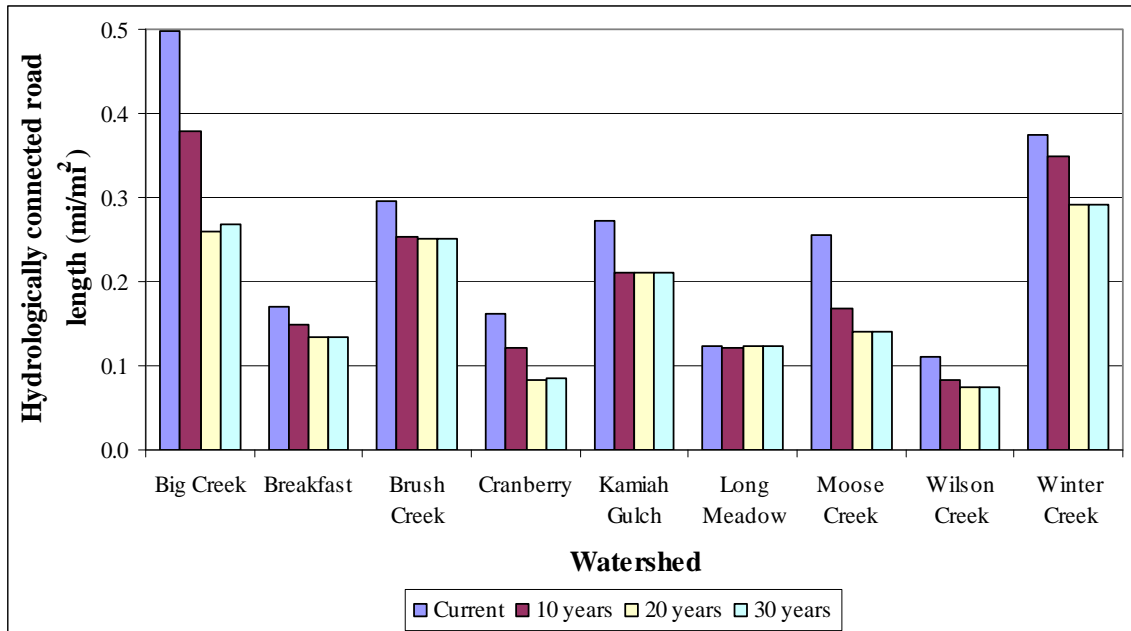


Figure III.C-6 Hydrologically connected road length (miles per square mile) in FAAs

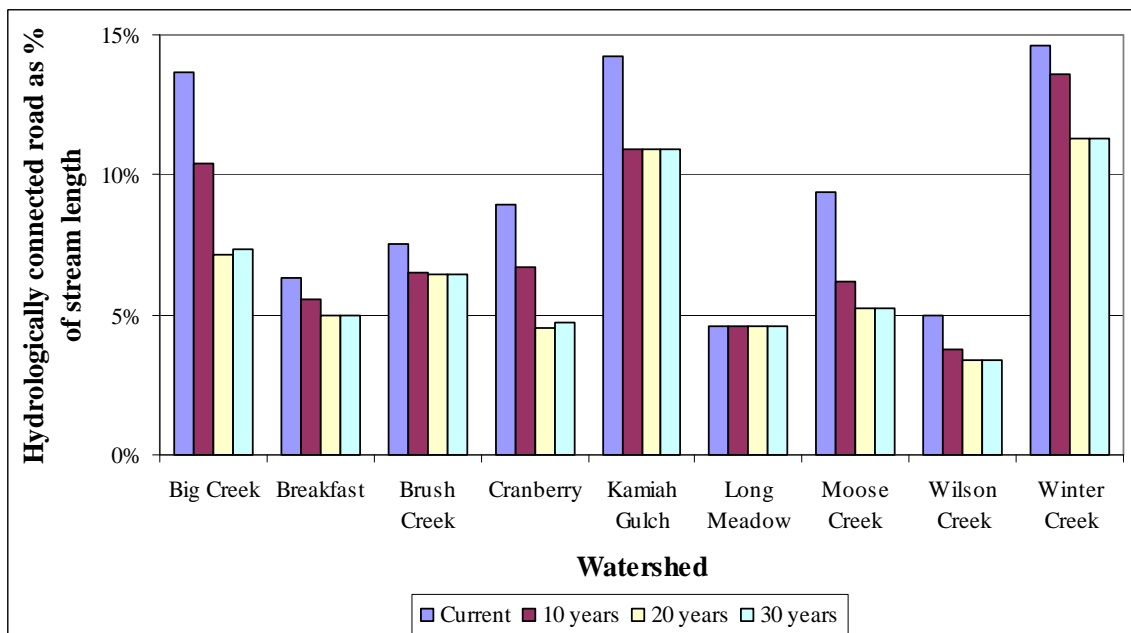


Figure III.C-7 Hydrologically connected road length (as percent of stream miles) in FAAs

The third column of Table III.C-3 shows the hydrologically connected road length compared to total watershed area, which is also illustrated in Figure III.C-6. The fourth column of Table III.C-3 shows the hydrologically connected road length compared to total stream length (Class I and II) in the watershed, and is illustrated in Figure III.C-7. The length of road directly connected to the stream system will be reduced due to IFP measures by 0 percent to 47 percent, with an average of 28 percent. This 28 percent estimate prepared from the specific road data gathered for the FAA watersheds compares favorably with the estimate of 20 percent developed from the more general approach presented earlier based on the data developed for the IDEQ study (WWA 2000), which was considered likely to be conservatively low.

III.C.4. Fish Passage

III.C.4.a. General Effects

Existing fish passage conditions at forest road culverts throughout lands regulated by Idaho's FPA were evaluated during CWE examinations of forested watersheds in 2003 and 2004 (Tretter 2005). One hundred ninety-eight (198) culverts were surveyed and evaluated for passage applying newly developed suitability criteria for gradient, maximum velocity, inlet drop, outlet drop, and minimum depth. Although not identical, these criteria are similar to those now proposed as physical criteria for evaluation of fish passage per the IFP: inlet drop, none; outlet drop, less than or equal to 4 inches; minimum depth, same as in representative riffle at low flow (Q_{95}); maximum velocity, 4 feet per second applied at a maximum culvert gradient.

Only five (3 percent) of the 198 culverts surveyed by Tretter (2005) met the criteria considered necessary for fish passage; 82 percent of them exceeded the maximum velocity criteria (approximately 4 feet per second), 19 percent exceeded the maximum inlet drop criteria (no drop), 26 percent exceeded the maximum drop at outlet criteria (1 foot), and 55 percent had inadequate depth at low flow (less than 3 inches).⁷ These results are not entirely unexpected given that many roads and culverts were constructed prior to accurate identification of streams where fish were present, and criteria considered to allow fish passage have changed over time, including development of the criteria applied in these surveys. For instance, many culverts were installed when placement at stream grade was considered appropriate, whereas today, placement at grade commonly is so steep that resultant velocities are considered impediments to fish passage.

The IFP road management measures require that Class I stream crossing culverts be designed to accommodate fish passage. For existing roads used for log hauling on enrollee lands during the life of the IFP, Class I stream crossing culverts must be reconstructed or replaced to provide for fish passage

⁷ Totals add to more than 100 percent because some culverts failed to meet multiple criteria.

according to a schedule to be implemented within 15 years of the landowner's date of enrollment to the IFP or within 1 year after completion of any harvest operation. Given the findings reported by Tretter (2005), it is likely that nearly all Class I stream crossings on enrolled lands not upstream from natural barriers would require improvement or replacement to provide for fish passage at some point during the life of the IFP. For IDL lands and other state and private lands enrolled upon or soon after implementation of the IFP, which potentially includes all state and private timberlands, these upgrades would essentially occur within the first 15 years of the IFP's 30-year life.

III.C.4.b. Specific Localized Effects (FAA)

Road and stream crossing information was collected throughout each of the nine FAA watersheds during the road erosion and sediment delivery inventory. These same data provide road and stream crossing density data generally representative of managed state and private lands throughout the action area.

Table III.C-4 Class I stream crossings in FAA watersheds

| Watershed | Area (acres) | Road length ¹ (mi) | Class I stream crossings | Crossings/mi ² | Crossings/road mile |
|---------------|--------------|-------------------------------|--------------------------|---------------------------|---------------------|
| Big Creek | 4,190 | 96.0 | 16 | 2.44 | 0.167 |
| Breakfast Cr. | 8,540 | 365.0 | 10 | 0.75 | 0.027 |
| Brush Creek | 3,950 | 92.9 | 6 | 0.97 | 0.065 |
| Cranberry Cr. | 9,100 | 337.7 | 28 | 1.97 | 0.083 |
| Kamiah Gulch | 2,930 | 60.6 | 9 | 1.97 | 0.149 |
| Long Meadow | 7,060 | 149.0 | 1 | 0.09 | 0.007 |
| Moose Creek | 4,970 | 156.0 | 10 | 1.29 | 0.064 |
| Wilson Creek | 3,930 | 150.0 | 4 | 0.65 | 0.027 |
| Winter Creek | 7,400 | 253.8 | 25 | 2.16 | 0.099 |
| --Average-- | --- | --- | --- | 1.36 | 0.076 |

- 1 Current road length not including abandoned roads. Stream crossing culverts generally must be removed before roads can be accepted as abandoned; they rarely remain on abandoned roads.

Additional information was also collected for one of these FAA watersheds that allowed examination of the costs and benefits associated with Class I stream crossing replacement. In October 2004, an IDL technical team assessed all streams in the Cranberry Creek watershed for the presence of fish and/or

potential fish habitat consistent with the IFP terms for Class I streams. Then the criteria considered necessary for fish passage, as discussed above, were used to assess each road crossing of these Class I streams. Sixteen Class I stream crossings were identified and assessed (Figure III.C-8).⁸ None of these crossings fully provides fish passage according to the passage criteria.

⁸ Numbers of Class I stream crossings from this detailed inventory are based on field-verified fish presence or suitable habitat. For Cranberry Creek, impassible natural barriers associated with basalt flow cliffs were located on a number of small streams, and therefore there are fewer Class I streams and Class I stream crossings than indicated by the road inventory. Verification of stream classifications is a requirement of the IFP as it is implemented.

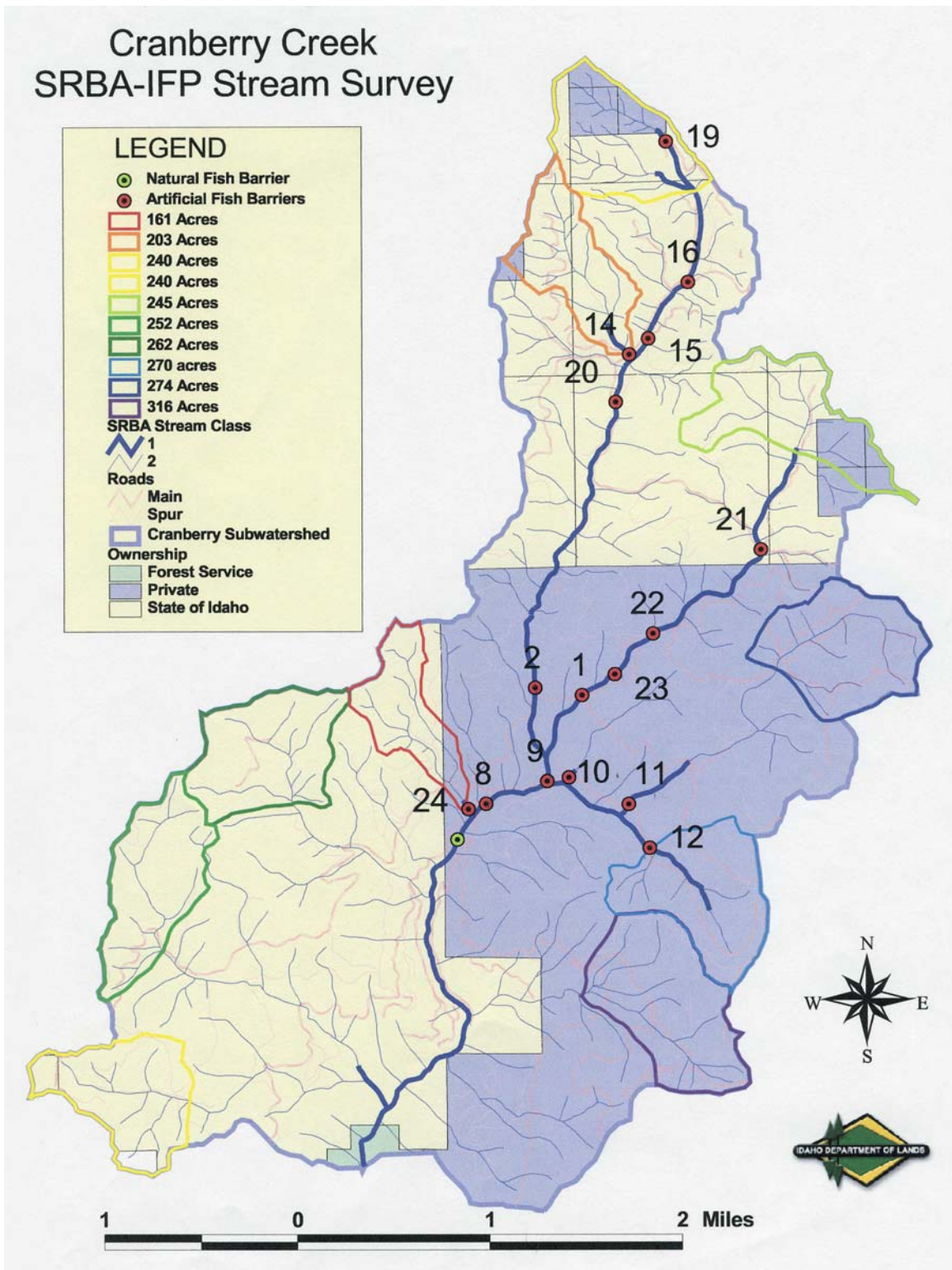


Figure III.C-8 Cranberry Creek stream crossing and potential fish barrier locations

The benefits and costs of addressing crossings in Cranberry Creek were also assessed. Benefits were assessed in terms of the upstream habitat area that would be added as each culvert was addressed. Habitat area that would be added as each crossing was addressed was computed as the incremental length from that crossing to the next “barrier” crossing multiplied by the channel width at the downstream crossing, thus providing a conservatively high estimate of this area. Cumulative benefit and cost was then assessed through accrual of benefits and costs as each culvert was addressed beginning with the mainstem crossing located lowest (downstream) in the watershed and working progressively upstream to add additional habitat area. Tributary streams were then assessed in a similar fashion. For Cranberry Creek, the exercise begins with crossing number 8, where 12,000 feet of channel providing some 180,000 square feet of habitat lie below this first culvert barrier, and where an incremental 6,159 feet of channel and 92.4 square feet of habitat would be provided between crossing numbers 8 and 12.

Table III.C-5 Cranberry Creek culvert costs and benefits

| Crossing | Length (ft) | Channel width (ft) | Channel area (kft²) | Cost (k\$) |
|-----------------|--------------------|---------------------------|---------------------------------------|-------------------|
| 0 | 12,000 | 15 | 180.0 | 0 |
| 8 | 6,159 | 15 | 92.4 | 35 |
| 9 | 4,820 | 8 | 38.6 | 15 |
| 2 | 8,152 | 8 | 65.2 | 35 |
| 20 | 2,177 | 3 | 6.5 | 5 |
| 15 | 2,667 | 3 | 8.0 | 5 |
| 16 | 5,354 | 3 | 16.1 | 15 |
| 1 | 1,082 | 8 | 8.7 | 15 |
| 23 | 1,605 | 6 | 9.6 | 15 |
| 22 | 4,164 | 3 | 12.5 | 35 |
| 21 | 3,131 | 3 | 9.4 | 5 |
| 12 | 2,545 | 3 | 7.6 | 15 |
| 14 | 1,071 | 2 | 2.1 | 5 |
| 11 | 2,098 | 5 | 10.5 | 50 |
| 19 | 445 | 2 | 0.9 | 15 |
| 10 | 294 | 4 | 1.2 | 35 |
| 24 | 277 | 3 | 0.8 | 35 |
| Total | 58,041 | | 470.1 | 335 |

The costs and benefits of this approach are then examined through marginal benefits analysis by plotting cumulative benefits as habitat area versus cumulative costs in Figure III.C-9.

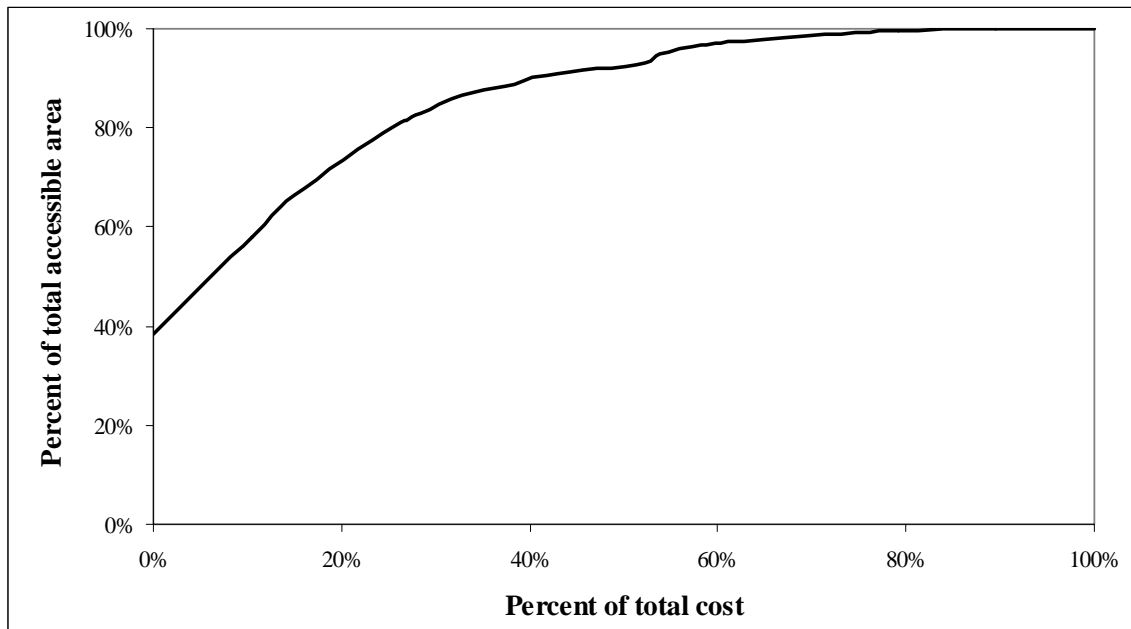


Figure III.C-9 Cranberry Creek culvert costs versus benefits

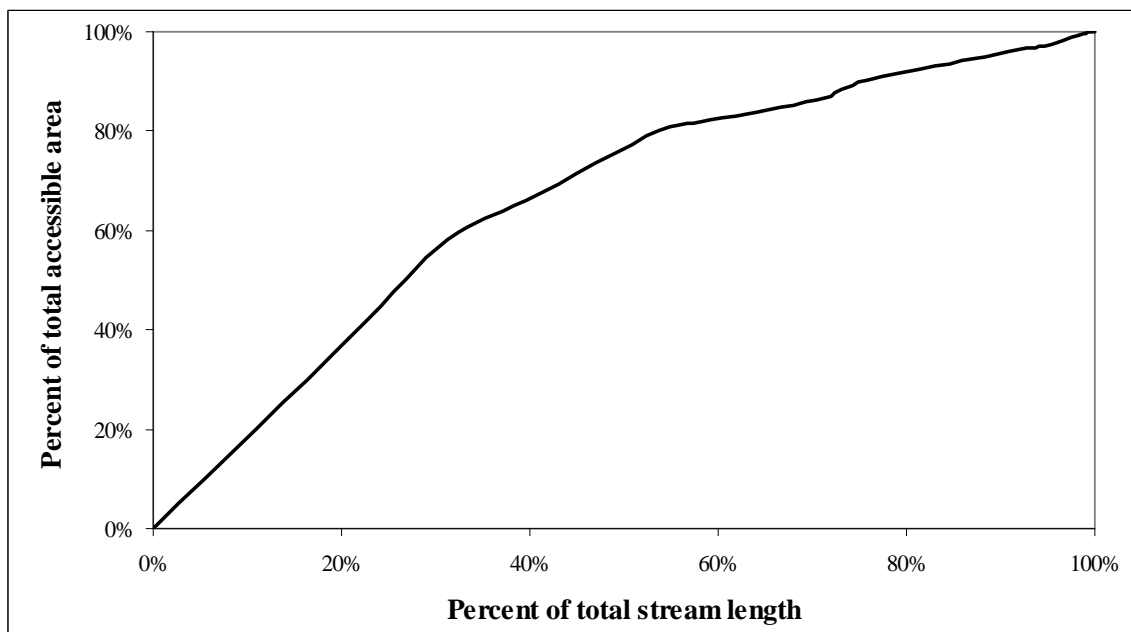


Figure III.C-10 Cranberry Creek culverts - area versus stream length

As indicated by Figure III.C-9 and Table III.C-5, 90 percent of all potential habitat area in Cranberry Creek is provided once crossings numbers 8 through 23 (eight crossings) have been addressed for an estimated cost of \$140,000, 42 percent of the total cost for all 16 crossings in the watershed. (Figure

III.C-10 illustrates that 90 percent of potential habitat area is represented by 75 percent of the total stream length.) The additional 10 percent of potential habitat would require replacement of an additional eight crossings for an additional cost of \$195,000.

This cost-benefit analysis example helps illustrate how enrollees and the IDL could approach prioritization and scheduling to provide fish passage. Moreover, many watersheds may never have true potential to provide access and habitat for the listed species covered by the IFP. Indeed, this is the case for Cranberry Creek - a natural barrier exists downstream of culvert number 8, and replacement of all or any of the stream crossings in the watershed will not provide additional habitat for the covered species. This analysis also suggests adaptive management opportunity wherein additional analysis of costs and benefits to the covered species could be assessed and reevaluated as the IFP is implemented on enrolled lands.

In summary of the benefits that may be provided by the IFP as fish passage conditions are assessed and corrected where required by the IFP terms, it is certain that many crossings will be replaced or reconstructed so that they provide fish passage. However, the number, location, and additional habitat area that may be provided for covered species by addressing stream crossings can only be roughly estimated as a range of possible effects based on combination of findings from the FAA watersheds, the additional data developed for Cranberry Creek (i.e., habitat area per stream crossing), and the area of potentially enrolled lands in watersheds where these species occur. Using this approach, area of habitat that may generally become available as a result of stream crossing improvement for fish passage in each of the FAA watersheds is provided in Table III.C-6 based on the average habitat area associated with stream crossing improvement developed for Cranberry Creek (18,000 square feet). A generalized estimate of the average habitat area that potentially may become available per square mile of enrollable lands computed from Table III.C-6 is 24,000 square feet.

Table III.C-6 Estimates of Class I stream habitat area potentially available through improvement or replacement of culverts on existing roads in FAA watersheds

| Watershed | Crossings/mi² | Class I stream habitat area per crossing (kft²) | Potential additional Class I stream habitat area per mi² of watershed (kft²) |
|------------------|---------------------------------|---|---|
| Big Creek | 2.44 | 18 | 44 |
| Breakfast Cr. | 0.75 | 18 | 14 |
| Brush Creek | 0.97 | 18 | 17 |
| Cranberry Cr. | 1.97 | 18 | 35 |
| Kamiah Gulch | 1.97 | 18 | 35 |
| Long Meadow | 0.09 | 18 | 2 |
| Moose Creek | 1.29 | 18 | 23 |
| Wilson Creek | 0.65 | 18 | 12 |
| Winter Creek | 2.16 | 18 | 39 |