HYDROLOGY

Introduction

This section will examine the hydrologic effects of wildfire on the forested environment of the West Side Reservoir Project. The climate, geology, geomorphology, management history, and proposed actions will be analyzed to determine the potential changes to the chemical and physical nature of water on the West Side Reservoir Project.

Information Sources

Information sources used in this document include data gathered by personnel from the Flathead National Forest (FNF) and the Montana Department of Fish, Wildlife, and Parks (MTFWP). Data used for the primary analysis of the hydrologic effects from the fires of 2003 was derived from Burn Area Emergency Rehabilitation (BAER) reports, and the natural resource databases maintained by the FNF. Scientific literature that was developed locally and literature pertinent to the topic based on similar physical, chemical, biological or issue parameters were considered and cited.

Computer Models Used for Evaluation

Two computer models were used in this assessment of the effects on hydrologic function from the wildfires of 2003. Northwestern United States data and Flathead National Forest specific data was used during development of both models. Although specific quantitative values for water yield and sediment increases are generated by the models, the results are estimates to be used as tools to interpret how the natural system may respond. Model output is meaningful when used to evaluate existing conditions in light of the area watersheds and stream characteristics, field data, and best professional judgment. The modeling results are interpreted in combination with the physical channel stability measurements to determine risk of channel erosion within an individual watershed.

R1WATSED model was used to estimate increased water yields from individual basins that experienced wildfire and subsequent salvage timber harvest and road use in the watershed groups. R1WATSED uses the procedure discussed in "Forest Hydrology, Hydrologic Effects of Vegetation Manipulation, Part II, (U.S. Forest Service, 1976). The procedure uses the equivalent clearcut acres (ECA) concept to estimate water yield. Additionally, it uses elevation, aspect, and precipitation to estimate the water yield increase resulting from removal of over-story vegetation cover from an acre of forestland. Water yield decreases for a harvested area as the vegetation recovers. The rate of decrease is based upon habitat type (U.S. Forest Service, 1976). It should be noted that the model calculates the estimated water yield increases from a fully forested condition. This is a slight over-estimation for the water yield increase by watersheds in these groupings due to the shallow rocky soils in the headwaters area and the presence of wet meadows, marshes and ponds with no forest cover.

The surface erosion potential for pre-fire, post-fire and proposed treatments within each landtype in each watershed grouping were estimated using the Water Erosion Prediction Project (WEPP) computer model. The DISTURBED WEPP interface of the model calculates the runoff and erosion from a hill slope. The output includes: inches of precipitation (Bigfork station), frequency and runoff from rainfall events, frequency and runoff from snowmelt events, upland erosion rate, potential sediment yield, and the probability of erosion and sediment delivery during the time period. The absolute soil erosion values that DISTURBED WEPP calculates for a given slope condition must be viewed with some caution because the model documentation states that a wide confidence interval surrounds the calculated values. Soil scientists using the model for this analysis found the calculated erosion rates to be very reasonable for these hill slopes and treatment conditions.

The WEPP – ROAD interface of the model was used to estimate non-point sediment sources from roads within the analysis areas. The same climate parameters were used as the hillslope portion of the model. Additional parameters input to the model were road width, slope, and ditch length to road-stream (RS) crossings. For complete documentation on the WEPP model refer to the Internet website http://forest.moscowfsl.wsu.edu/fswepp.

Analysis Area

The West-Side Reservoir Project is divided into three primary analysis areas formed by grouping watersheds burned during the Blackfoot Complex fires of 2003. The Beta-Doris group consists of the first cluster of burned watersheds on the west side of Hungry Horse dam and is displayed in Figure 3-14. The Doe-Blackfoot group is the second cluster of burned watersheds and includes the Wounded Buck watershed which sustained burning from both the Doe fire and the Blackfoot fire (Figure 3-15). The Beta-Doris and Doe-Blackfoot watershed groups occur on the Hungry Horse Ranger District. The third cluster of burned watersheds is the Ball group, located the furthest south along the west side of the reservoir. The Ball watershed group occurs on the Spotted Bear Ranger District and is illustrated in Figure 3-16.

Affected Environment

Historical Perspective

The Flathead Forest Reserve was created in 1897 and included the South Fork of the Flathead River drainage. Hungry Horse dam was constructed on the South Fork from 1948 to 1953. During dam construction, new roads on the east and west sides of the river above the projected water level of the new reservoir were built from the dam site to Spotted Bear Ranger Station. Anna Creek and Betty Creek Work Centers were built about half way down on the west and east sides of the reservoir, respectively. Several campgrounds and boat launches were constructed in the 1960's for the public to enjoy full advantage of the amenities offered by the reservoir.

Figure 3-14. Watersheds grouped for analysis from the Beta – Doris

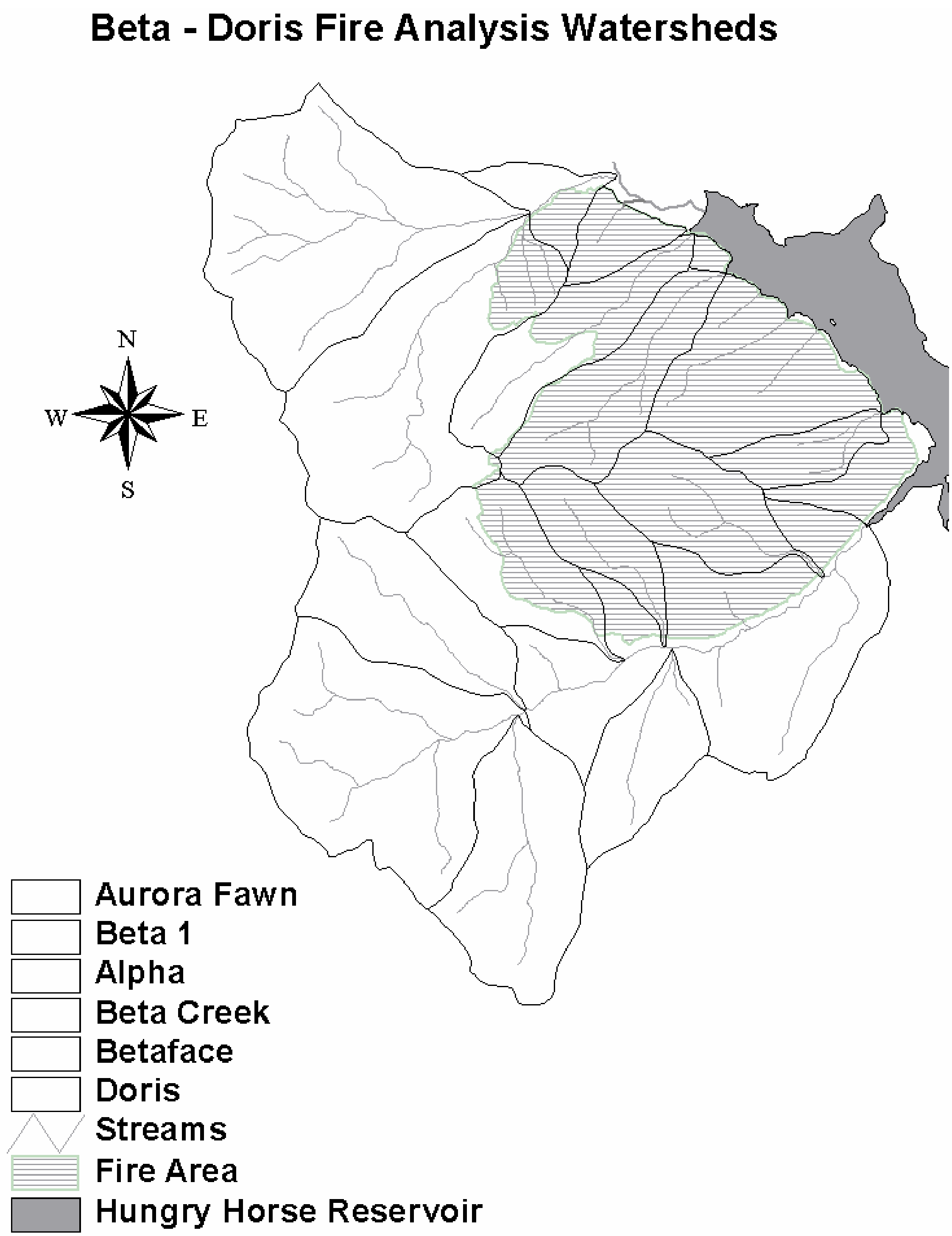


Figure 3-15. Watersheds grouped for analysis from the Doe and Blackfoot Fires.

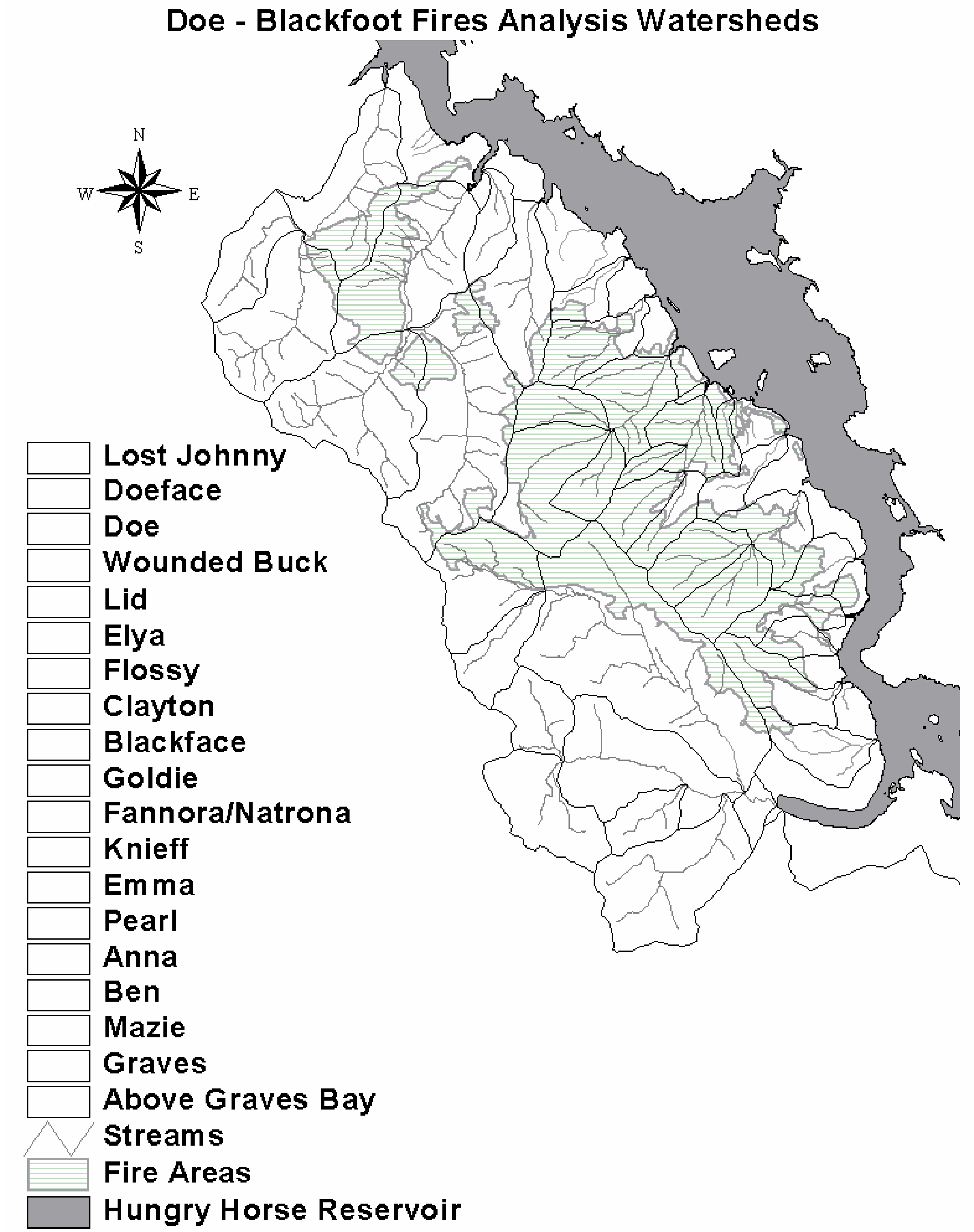
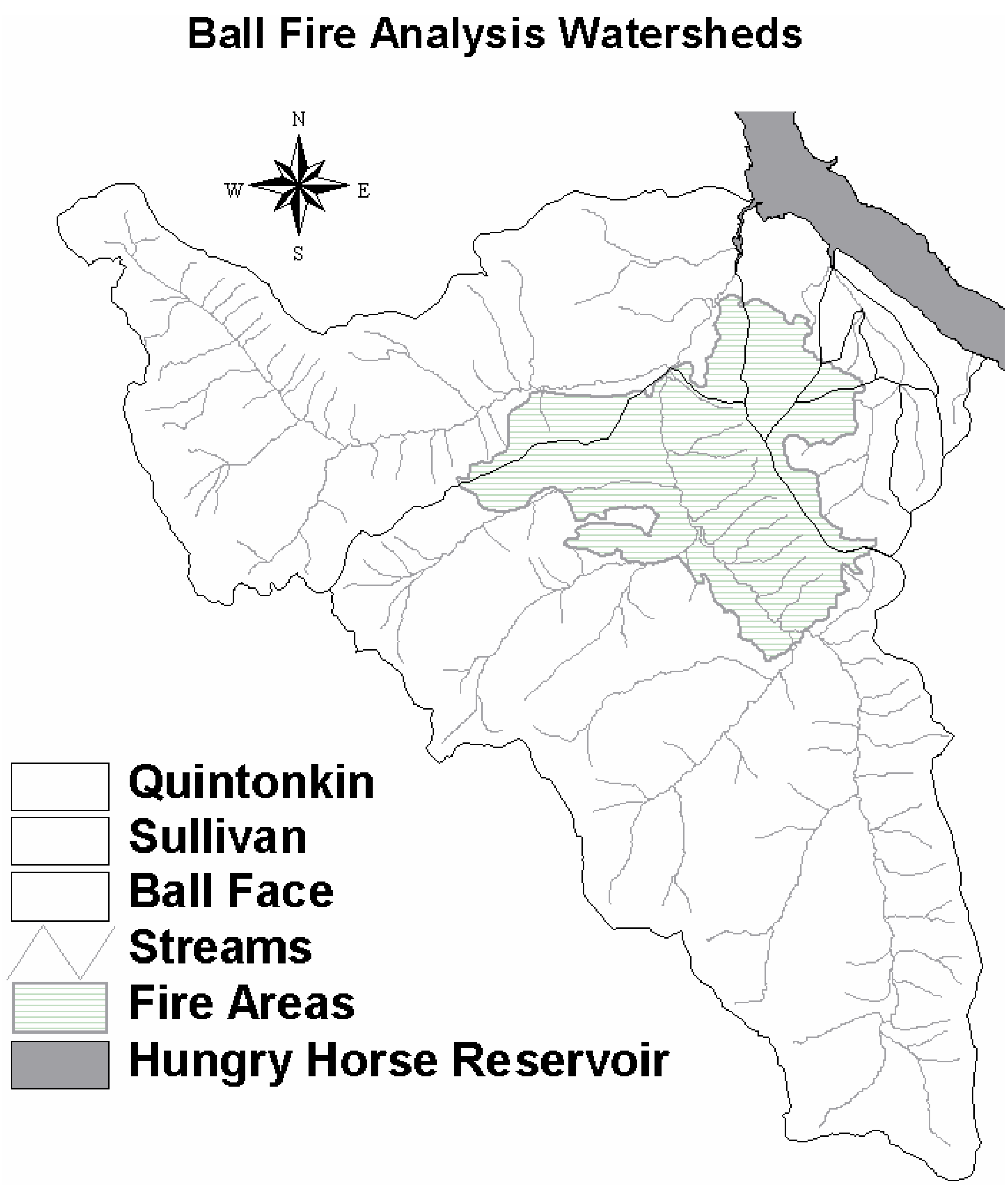


Figure 3-16. Watersheds grouped for analysis from the Ball Fire.



Geology

Extensive surficial deposits of alluvium, glacial till, glacial outwash, and lacustrine sediments mantle the FNF. The glacial till was deposited by continental ice sheets and tends to be heavy with a bulk density of 1.5 to 1.8 grams per cubic centimeter (USDA, 1998). The following four geomorphic groups are common throughout the FNF and have associated landform and soil properties: alluvium; lacustrine deposits; glacial outwash; and glacial till.

Alluvium: is unconsolidated material sorted and deposited by water. The rock fragments are generally rounded. Alluvium forms flood plains, fans, and terraces along the major streams. Flooding, fluctuation of the water table and the necessity to protect stream banks and channels from mass wasting can limit management of soils formed from alluvium.

Lacustrine deposits: are unconsolidated silts and rock flour deposited on glacial lake bottoms. These deposits are typically varved with thin sedimentary layers resulting from seasonal variations in deposition. Terraces with gently sloping surfaces and steep risers are formed in lacustrine deposits. Soils formed in lacustrine sediments are erodible when exposed by excavations and have low strength when wet.

Glacial outwash: is material moved by glaciers and subsequently sorted and deposited by streams flowing from melting ice sheets. Glacial outwash forms terraces with nearly level surfaces and steep risers. Soils formed in glacial outwash have sandy substratum with rounded pebbles and cobbles.

Glacial till: consists of unconsolidated deposits of rock flour, sand, gravel, and boulders deposited by a glacier. Eskers, lateral moraines, and terminal moraines are scattered over the landscape of the FNF. Glacial till mantles mountain slopes and ridges in the FNF. Soils formed from glacial till are hard and brittle when moist and restrict the penetration of roots and the movement of water.

Climate

The weather variations for the entire Flathead region are due to the influence of maritime patterns from the Pacific Ocean. The general easterly flow by lower layers of the atmosphere common at this latitude of the Pacific Northwest are modified by the mountain complexes of Western Montana and Central Idaho. The high mountains in the Continental Divide, directly east of the Flathead region, form an effective barrier to severe cold Artic patterns flowing south on the Great Plains through Canada. The valleys experience many days with dense fog or low stratus cloud layers during the winter months due to radiational cooling of dense, valley bottom air with relatively warmer Pacific source air moving over the top.

Precipitation varies widely with season, elevation and location. The greatest percentage of precipitation falls as snow during winter months. The weather station at Hungry Horse Dam, MT (station I.D. 244328) was used to characterize the precipitation of the South Fork of the Flathead (Western Regional Climate Center, 2003).

Table 3-38. Average Total Precipitation at Hungry Horse Dam (inches)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Hungry Horse Dam	3.53	2.61	2.31	2.29	2.80	3.43	1.78	1.79	2.28	2.89	3.72	3.67
Period of Record = 7/2/1948 to 12/31/2002 Annual Mean (inches) = 33.10												

Some precipitation occurs every month of the year. Most winter precipitation in the mountains occurs as snow, although some rain on snow events are documented. Density of the mountain snow pack increases from about 20% water equivalency in early winter to about 35% in April.

Table 3-39. Average Total Snowfall at Hungry Horse Dam (inches)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ave. Total	23.5	14.4	9.2	1.1	0.2	0.1	0.0	0.0	0.0	1.7	8.1	21.1
Ave Depth	12	14	10	1	0	0	0	0	0	0	2	4
Period Record = 7/2/1948 to 12/31/2002 Annual Mean Total = 79 Annual Mean Depth = 4												

Streamflow begins to increase in April as the snow pack melts with warming spring temperatures. Peak streamflow usually occurs in late May or June. Not all snowmelt or rainfall immediately becomes surface runoff. Portions may infiltrate to become groundwater that percolates downward into the soil and bedrock and resurfaces in wet areas, small ponds, and perennial streams at various elevations below the point of infiltration. Slow release of groundwater provides stream baseflow beginning in mid-July and continuing until fall rains begin in mid-September.

Stream Type Characterization

The Rosgen Stream Classification System provides a method for identifying streams according to morphological characteristics (Rosgen, 1996). The morphological characteristics include factors such as channel gradient, sinuosity, width/depth ratio, dominant particle size of bed and bank materials, entrenchment of channel and confinement of channel in valley. A Rosgen Stream Type Classification (level –1) was developed for the Flathead National Forest in 1999 using digital elevation models (DEMs). The computer model only reliably identifies A, B, C, and E stream types. Stream types in analysis watershed groups were extracted from the Rosgen coverage in the GIS library.

The stream types summarized below are described at depth in Rosgen, 1996:

- A-type: streams with gradients 4 to 10 %, characterized by straight, non-sinuous, cascading reaches with frequently spaced pools;

- B-type: streams with gradients 2 to 4 %, moderately steep, usually occupy narrow valleys with gently sloping sides;
- C type: streams with low gradients < 2% with moderate to high sinuosity and low to moderate confinement;
- E-type: streams with gradients < 2%, high sinuosity, and moderate confinement; gravel and small cobble channel bottoms and silt or clay banks.

Landforms

Climate, bedrock and geomorphic processes combine to create various landforms. Landforms generated by the geomorphic groups above and the resultant vegetation are the dominant physical features that affect watershed processes. Landforms regulate how and where water (climate) flows across the landscape. Vegetation influences the erosion processes that occur within the landscape. Landforms common in the watershed analysis groups are presented in Table 3-40 and described below: valley bottoms; breaklands; steep, alpine glaciated lands; glaciated lands; mountain slopes and ridges; and mass wasting slopes.

Disturbances such as fire and timber harvest release nutrients from vegetation and soil. Many of the nutrients end up stored in soil and available for plants. Some nutrients end up in streams and ultimately in the Hungry Horse Reservoir. The potential nutrient contribution for each individual landform is rated from low to high in Table 3-40. The nitrogen yield rating is based on the natural level of nitrogen in the soil, soil permeability and precipitation. The phosphorus yield is based on the natural level of phosphorus in the soil and the sediment hazard.

Sensitive soils are another important component of landforms and typically have excess water in the soil profile, usually only on a seasonal basis but sometimes on a year round basis. The sensitive soils in a natural, undisturbed condition act as temporary storage for water, releasing water that does not infiltrate deeper into the groundwater regime through surface discharge release as springs, seeps and wetlands. When sensitive soils are disturbed by management activities such as road building or timber harvest, water can move out of the soil profile and onto a road, skid trail or landing and then quickly down slope. Water that would naturally have moved slowly down-gradient to a stream or infiltrated to groundwater is now quickly routed into a stream. This effective routing of water increases peak flows and increases the risk of stream channel erosion.

Mountain slopes and ridges: occur in both the upland and alpine landscape settings and are typically composed of dissected mountain slopes, glaciated mountain slopes, and glacially scoured ridge tops. The geomorphic processes that occur on these areas include colluvial, fluvial and glacial, erosion or deposition. Parent materials are volcanic ash overlying bedrock composed of argillites, siltstone, quartzite, and limestone. The vegetation is a mosaic of coniferous forest, mountain shrub lands, and mountain grasslands.

Glacially scoured ridge tops have been strongly modified by continental ice. The prominent features are ridge tops and ridge noses with exposed bedrock. These areas have slopes that range from 10% to 45%. Soils are shallow to moderately deep, and are weak to moderately developed with medium textures. Slopes range from 30 to 60%.

The mountain slopes landform is moderately to strongly dissected by ephemeral and perennial streams that occupy narrow “v” shaped valleys, with the dominant stream pattern either dendritic or sub-parallel. Streams are typically classified as A or Aa+ types with gradients from 4% to 10% and are characterized by straight (non sinuous) cascading reaches and frequently spaced pools. When flowing on bedrock and boulders (A1 and A2) streams are very stable with low sensitivity to increases in water yields, peak flows or sediment. The streams in the ridge top landform position occur at the heads of drainages and are typically ephemeral or intermittent streams associated with seeps and springs.

The riparian vegetation is dominantly *Abies lasiocarpa / Streptopus amplexifolius, Abies lasiocarpa / Oplopanax horridium* and *Picea / Cornus stolonifera* riparian habitat types.

The nitrogen yield from this landform group is moderate and the phosphorus yield is low. There are no sensitive soils in this landform group.

Mass wasted slopes: are a complex mixture of colluvial soils of various textures and residual soils on rolling to steep mass failure lands. Soil permeability is rapid due to rock fracturing. Drainages are usually short and dry with pattern defined by dominant rock fracturing or bedding. Seeps, springs and small ponds occur at slope breaks. Slopes are complex and result from debris slides and rotational slumps. Topography is subdued by secondary mass wasting on dipping bedrock associated with block gliding. Elevation ranges from 4,000 to 6,000 feet above mean sea level. The parent material is predominantly residuum derived from the underlying bedrock and colluvium deposited by mass failure. The parent material has a wide variety of physical and chemical properties depending on the degree of weathering and the bedrock source. The soils formed in colluvium occur on benches deposited by mass failure and are pale brown, silt loam volcanic ash-influenced loess. Slopes on benches of colluvium are 30%. Soils formed in residuum occur on the steep scarps above the colluvial deposits and slopes are 50%. Residuum soils are brown, very gravelly loam glacial till that is neutral to medium acidic. The residuum soils have 45% to 80% angular coarse rock fragments.

The major habitat types on the benches with colluvium are *Abies lasiocarpa / Clintonia uniflora, Abies grandis / Clintonia uniflora*, and *Thuja plicata / Clintonia uniflora.* The major habitat types on the scarps that have residuum soils are *Abies lasiocarpa / Xerophyllum tenax*, and *Abies lasiocarpa / Meniesia ferruginea*.

The nitrogen yield for the colluvium and residuum soils are moderate and the phosphorus yields are moderate to high, depending on the amount of chemical weathering that has taken place and the position of the soils in the hydrologic landscape. Both soils are sensitive.

Riparian and Wetland Areas: The east flank of the Swan Range is a steep dip slope dotted with small lakes, ponds, marshes and tiny wetlands formed as snow gradually melts from bedrock and then percolates into glacial till. The Flathead National Forest maintains a mapped inventory and description of riparian and wetland areas on non-wilderness lands in the Riparian Landtype Inventory coverage in the GIS library. Approximate riparian and wetland acreages within the analysis areas are included in Table 3-40 and were generated by intersecting the burn area and landform area with the riparian layer. The actual areas of riparian and wetland areas would only be accurately delineated after timber sale cruising and layout. There may be small, unmapped riparian zones that occur around pocket wetlands, and intermittent or ephemeral channels.

Watershed Current Condition Assessment

Three major characteristics describe the existing condition of a watershed:

- Stream channel condition;
- Water quantity;
- Water quality.

Water quality is subdivided into sediment concentrations and nutrient concentrations. A short discussion follows of the existing condition of the major characteristics with summarizations of applicable scientific literature to illuminate the issues of concern.

Stream Condition Surveys

Channel bank stability in the Flathead National Forest

Streams do not have 100% stable banks due to natural conditions such as: channel wander through floodplains, floods, glacial geomorphology creating cobble bed channels, and trees toppling into streams. Research has found that land management activities such as timber harvest and associated road construction can reduce bank stability (Overton et al, 1995). Stream bank stability also varies by channel type. The classification system developed by Rosgen (1996) is useful to stratify channel types. The most common channel types on FNF are A, B, C, and E channel types.

Since 1990, FNF has surveyed 52 stream reaches that are Rosgen A channel types and found that on average 92.3% have stable banks. These surveys have taken place across the entire forest, some in wilderness, and others in managed areas. Of the 52 stream reaches, 7 were considered pristine and averaged 89.2% bank stability. The lower pristine average is due largely to data collected in Cox Creek in the Bob Marshall Wilderness, which was surveyed shortly after a flood that resulted in substantial bank migration (Gardner, 2001).

Rosgen B channels had similar findings of bank stability regardless of setting (wilderness vs. managed). FNF has surveyed 79 B channel stream reaches since 1990 and found the average stability was 86.9%. Of these 79 reaches, 10 were in pristine settings that averaged 87.8% stable banks.

Rosgen C channels are less confined in riparian valleys and therefore are expected to have less bank stability than A or B channel types. A total of 54 C channel stream reaches have been surveyed since 1990 and averaged 77.4% bank stability. Of these 54 reaches, a total of 16 were in pristine settings that averaged 79.2% bank stability (Gardner, 2001).

To assess the potential effects of the fire to the dynamic equilibrium of streams in the analysis watershed groups, field crews conducted stream condition surveys within the burn perimeters during September and October, 2003. Pfankuch ratings, Wolman pebble counts and cross-section data was collected. The Pfankuch stream channel rating was developed to "systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production" (USDA Forest Service, 1978). The procedure uses a qualitative measurement with associated mathematical values to reflect stream conditions. The rating is based on 15 categories: 6 related to the channel bottom covered by water yearlong; 5 related to the lower banks covered by water only during spring runoff; and 4 related to the upper banks covered by water only during flood stage. Streams rated *excellent* (<38) or *good* (39 – 76) are less likely to erode during high flow that streams with ratings of *fair* (77 – 114) or *poor* (115 +). Ratings are evaluated at a spot or reach of stream. Each rating represents one point in time and a series of rating must be made over several years to show trends in stream stability. Prime fish habitat is generally found in stream segments with good or fair ratings. Excellent rated segments do not have adequate small gravels for spawning habitat. Pfankuch data sheets are contained in Exhibit G-1 and the overall results are summarized in Table 3-41.

Wolman pebble counts provide an estimate of the distribution of particles sizes in a stream reach. Pebble count data can be interpreted to compare median particle sizes between streams, evaluate the percent fines less than a specific size, and compare particle distributions between streams. Threshold pebble count values have not been developed in Montana. New Mexico has established surface sediment thresholds for aquatic life support. Streambeds that have less than 20 percent fines (<2mm, by pebble count) are considered fully supporting aquatic life beneficial uses. The results of a study conducted by the U.S. Forest Service (Rober et. al., 2002) suggest pebble count data can vary considerably and variation can be attributed to both differences among streams and differences in how observers evaluate streams.

McNeil core samples are another measure of channel substrate composition. Samples are typically extracted from areas utilized by bull trout for spawning to assess the quality of the spawning habitat. Spawning is considered threatened when the percentage of material < 6.35 mm exceeds 35% of the sample, and impaired when it exceeds 40%. The MFWP collects McNeil core samples in cooperation with the FNF. The only stream within the project area for which McNeil core data is collected is Wounded Buck Creek. Latest results are presented in Tables 3-42 and Table 3-43. Little Salmon and Youngs Creeks are contained within the Bob Marshall Wilderness Area and are included to reflect the McNeil core data from non-managed streams.

Substrate scores are an overall assessment of streambed particle size and embeddedness and involve visually assessing the dominant and subdominant streambed substrate particles, and Wolman pebble counts. Over time, substrate scores provide an index of juvenile bull trout rearing habitat quality. A score below 10 indicates the level where rearing capacity (FBC 1991) is threatened and scores less than 9 indicate rearing capacity is impaired. Substrate score data are available for Wounded Buck and Quintonkon Creeks within the project area.

Table 3-41: Summarization of stream channel surveys

Watershed	Number of Surveys	Average Pfankuch Reach Score
Alpha Creek	1	51
Below Doris to HH dam 1-3	10	60
Ben Creek	4	76
Clayton Creek	5	76
Clayton Tribs.	8	91
Doris Creek	3	60
Emma Creek	1	63
Flossy Creek	5	76
Flossy Tribs.	4	62
Goldie Creek	4	86
Goldie Tribs.	10	92
John Creek	2	75
Knieff Creek	2	83
Knieff Tribs	2	59
Pearl Creek	4	64
Wild Cat Creek	2	64
Wounded Buck Creek	3	62

Table 3-42: Median percentage of streambed material smaller than 6.35mm in McNeil core samples collected from West-slope Cutthroat and Bull Trout spawning in the South Fork drainage from 1994 – 2002.

STREAM	1994	1995	1996	1997	1998	1999	2000	2001	2002
Wounded Buck	31.6	29.9	31.2	33.0	30.6	31.9	31.1	30.4	32.3
Little Salmon	--	27.1	17.4	19.0	--	--	--	--	--
Youngs	--	30.2	25.3	27.2	--	--	--	--	--
Emery	31.2	30.7	32.7	34.1	35.0	34.6	34.9	33.2	34.1
Tiger	30.8	31.9	32.0	34.1	31.6	32.0	33.6	32.1	34.0

Table 3-43 Substrate scores collected from tributaries to the South Fork of the Flathead from 1987 through 2003. These streams provide juvenile rearing habitat for the Hungry Horse bull trout population.

STREAM	1987	1988	1995	1996	1997	1998	1999	2000	2001	2002	2003
Wounded Buck	--	--	12.6	12.8	13.0	12.8	13.1	12.8	12.5	12.2	12.6
Quintonkin	13.0	12.5	--	13.2	13.1	12.8	13.0	12.8	12.5	12.3	12.9

Water Quantity

Water Yield

The amount and timing of water flow from a basin is a major characteristic of a watershed. When forest vegetation is either removed during timber harvest or killed by wildfire there may be a hydrologic response of increased water yield from that site. Watersheds exhibit great natural variability in flow and can accommodate some increase in peak flows without damage to stream channels and aquatic organisms. Increases in average high flows can cause a variety of channel effects such as channel widening and deepening, bank and bottom erosion, and sediment deposition as bars or islands. Substantial increases in peak flows generally lead to a subsequent increase in sedimentation. If the amount of water yield increase is too much for the capacity of the stream channel, the amount of channel erosion increases proportionately.

The relationship between removal of vegetation by timber harvest and increases in water yield are well established (USDA Forest Service, 1976). The majority of the increase in water yield occurs during spring runoff (King 1989). Climate primarily determines the magnitude of large flood events (Duane and Leopold 1987); however, land use practices have been shown to increase peak flows (Troendle and Kaufman 1987). The reduction in tree density and canopy cover results in a reduction in the amount of transpiration of groundwater and a reduction of canopy interception of rain and snow fall. The amount of precipitation available for runoff is increased. Water yield returns to pre-harvest levels as the tree canopy recovers with re-growth. . The time frame for 100% hydrologic recovery for the habitat types that predominate on the Flathead National Forest can be in excess of 100 years (USDA 1995, Galbraith 1973). The stand-types and habitat types found in the West-side Reservoir Project area would normally be expected to have full vegetative and hydrologic recovery in approximately 90 years after a clearcut or stand replacement fire (Northern Region 1976) (Galbriath 1973).

Changes to Water Yield in Post Fire Situation

Extensive literature exists indicating that stream flows are increased after fires, through a combination of evapo-transporation reduction, soil-surface storage reduction, and snow accumulation. Water yield increases have been observed in watersheds with moderate to high vegetation burn intensities and moderate to high soil burn severities. The amount and duration of the water yield increase following wildfire varies depending upon the size of the fire and the intensity and severity of the burn.

McCaughey and Farnes (2001) monitored snow water equivalency for seven years in a natural dense canopy lodgepole stand and in an open meadow on the Lewis and Clark National Forest. The open meadow received 23% more snow water equivalent than the dense canopy. The melt rates under the canopy were 47% of the open meadow and the final melt out in the meadow was approximately 10 days earlier than the floor of the dense canopy. Skidmore et al. (1994) studied snow accumulation and ablation rates on the forest floor in natural lodgepole forests, burned forest sites, and clearcuts in southwestern Montana. The burned forest canopy, with cover reduced by 90%, had 9% more snow water equivalent than the mature, unburned forest stands. The ablation rate associated with the burned forest increased by 47% compared to the unburned stands. Skidmore et al. (1994) note that the forest structure of the burn and of the clearcut produced similar snow accumulation and ablation responses.

The increase in water yield has the most potential to cause short-term increases in channel erosion in several of the small 1st order streams in the West-side Reservoir Project due to the combination of burning of the riparian vegetation, and in some cases burning large woody debris within the streambanks, along with the naturally erodible streambank materials.

Water Yield Effects from the West Side Reservoir Fires

R1WATSED was used to model the potential increase in water yield as percent above normal from a fully forested condition for the analysis watershed groups. The model also calculates increases in ECAs and acre-feet (AF). The model parameters input include: area of the watershed within each precipitation zone, miles of road in the watershed within each precipitation zone, and analysis year. The model also includes parameter inputs for past harvest activities, habitat type, percent crown removal, and runoff factor. The coefficients (habitat types, timber management codes, soil types, slopes, aspects, etc) built into the model have been calibrated for the Flathead Basin by FNF and Montana Department of Natural Resources and Conservation (MDNRC) forest hydrologists. An EXCEL worksheet (Blank Flathead.xls) was developed to execute the model for the estimates in this document. Copies are contained in Exhibit G-2.

Model parameters were extracted from FNF library coverages and summarized by analysis watershed group. The summaries are contained in EXCEL worksheets for each analysis watershed group: Beta-doe Summary.xls; Ball Summary.xls; and BlackdoeSummary.xls, included in Exhibit G-3. The past harvest activity by watershed was input for analysis year 2003 to estimate the PRE-BURN condition. The pre-burn condition better reflects actual vegetation recovery from past timber harvest activities within a watershed than the model assumption of potential increases from a fully forested condition (Galbraith, 1973). The past harvest activity was then intersected with burn area by watershed. Areas of burned stands were subtracted from the pre-burn past harvest stands. The remaining past harvest activity was input for analysis year 2004 with the addition of the acreages for high and moderate burn intensity; low burn intensity and low / unburned intensity to estimate the AFTER-BURN or current condition of each analysis watershed group. The changes of water yield increase between pre-burn and after-burn conditions express the effects of the fires on the hydrologic function of each watershed. Results are presented in Table 3-44.

The following assumptions were made for acreages of burn severity used when calculating water yield increases. For the moderate and high burn severity areas by watershed, the actual acreages were input to the R1WATSED spreadsheet. For low burn severity areas, the actual acreage was reduced by 60% to reflect the reduced potential for soil erosion. The low / unburned (LUB) acreage was reduced by 60%. The 60% acreage was subtracted from the original LUB acreage and the remainder was further reduced by 40% to reflect the reduced potential for soil erosion in unburned polygons.

Equivalent Clearcut Area Increases from the West-side Reservoir Fires

The FNF lands surrounding Hungry Horse Reservoir have experienced on-going timber management activities since the dam was completed in 1953. The R1WATSED model generates an estimate of the ECA based on vegetative recovery from past timber management activities. This is a characterization of the amount of the watershed that can produce additional water yield. The PREBURN and AFTERBURN condition ECA's present another methodology to access fire effects and watershed hydrologic function. ECA results are presented in Table 3-45.

Table 3-44: Water Yield (WY) for analysis watersheds of the West-side Reservoir Project

Watersheds	Total area (acres)	PREBURN WY Increase %	AFTERBURN WY Increase %	Fire Effects to WY %
BETA – DORIS FIRES				
Aurora/Fawn Creek	4219	0.8	1.1	0.3
Betawtrsh1	241	0	26.2	26.2
Alpha Creek	754	3.4	5.0	1.6
Beta Creek	779	5.2	11.0	5.8
Betaface	1357	7.0	15.3	8.3
Mamie Creek	296	10.1	23.6	13.5
Doris Creek	8668	1.1	2.9	1.8
DOE – BLACKFOOT FIRES				
Wounded Buck Creek	10222	0.6	1.8	1.2
Lost Johnny Creek	6042	1.6	2.2	0.6
DoeBlackFace	3401	6.7	6.6	13.3
Doe Creek	701	8.9	8.6	17.5
Lid Creek	1771	5.5	5.7	11.2
Elya Creek	471	10.4	10.8	0.4
Flossy Creek	1043	5.8	10.4	4.6
Clayton Creek	4288	2.0	4.8	2.8
Goldie Creek	2411	3.9	15.4	11.5
Blackface	2357	10.1	10.9	0.8
FannoraNatrona Creeks	819	16.4	16.6	0.2
Knieff Creek	2885	4.4	13.8	9.4
Emma Creek	559	5.7	4.6	10.3
Pearl Creek	633	6.4	17.5	11.1
Mazie Creek	917	8.1	7.9	16.0
Ben Creek	1124	4.8	5.5	0.7
Anna Creek	447	19.1	19.1	0.0
Graves Creek	17817	0.4	0.8	1.2
BALL FIRES				
Sullivan	30932	0.9	2.7	1.8
Quintonkin	17722	1.2	1.1	0.1
Ballface	6203	3.4	6.5	3.1

Sedimentation

The amount of sediment routed to or eroded within a stream channel can affect the beneficial uses of water, and is frequently used as a measure of overall water quality. As stream channel size and shape have evolved to carry the historic sediment load, large increases in sediment yielded to a stream may exceed the streams ability to transport the load (Dunne and Leopold 1978). As a result, sediment deposition would occur in the stream channel, especially in low-gradient sections of a stream, as point bars and mid-channel bars. This leads to a wider, shallower, less stable channel than pre-deposition conditions, and can have a detrimental impact to the fisheries resource by clogging spawning gravels. Increased sedimentation also impacts macro-invertebrates and other aquatic organisms. Bank erosion may also be increased, thus adding even more sediment to the load in the stream.

Table 3-45: ECA for analysis watersheds of the West-side Reservoir

Watersheds	Total area (acres)	PREBURN ECA	AFTERBURN ECA	Fire Effects to ECA
BETA – DORIS FIRES				
Aurora/Fawn Creek	4219	89	123	34
Betawtrsh1	241	0	187	187
Alpha Creek	754	53	91	38
Beta Creek	779	109	241	132
Betaface	1357	209	516	307
Mamie Creek	296	72	179	107
Doris Creek	8668	257	776	519
DOE – BLACKFOOT FIRES				
Wounded Buck Creek	10222	193	639	446
Lost Johnny Creek	6042	234	352	118
DoeBlackFace	3401	480	481	961
Doe Creek	701	142	138	280
Lid Creek	1771	230	242	472
Elya Creek	471	127	133	6
Flossy Creek	1043	185	347	162
Clayton Creek	4288	286	727	441
Goldie Creek	2411	258	1110	852
Blackface	2357	491	542	51
FannoraNatrona Creeks	819	302	308	6
Knieff Creek	2885	324	1128	804
Emma Creek	559	141	121	262
Pearl Creek	633	114	340	226
Mazie Creek	917	176	172	348
Ben Creek	1124	141	168	27
Anna Creek	447	136	137	1
Graves Creek	17817	303	588	891
BALL FIRES				
Sullivan	30932	751	2668	1917
Quintonkin	17722	634	577	57
Ballface	6203	511	1092	581

A statistical analysis of the relationship between suspended sediment and stream discharge was completed for samples collected from 1976 through 1986 on the Flathead National Forest (Anderson, 1988). Rating curves and regression analysis for the Spotted Bear and Hungry Horse Ranger Districts were reviewed to estimate background sediment carrying capacity for this DEIS. Six monitoring stations in four watersheds were sampled on the Spotted Bear District and twelve monitoring stations in ten watersheds were sampled on the Hungry Horse District. A total of eighteen monitoring stations in fourteen watersheds were included in this estimate and occupy similar geologic and geomorphic provinces and similar precipitation regimes. Sampling was well represented throughout the annual hydrographs. Monitoring stations with weak suspended sediment / discharge correlations, few or no statistically significant regression equations, and low suspended sediment concentrations are generally characteristic of stream systems with very limited supplies of sediment. Of the six stations in the Spotted Bear District, four were in this category (Anderson, 1988). For the Hungry Horse

District, nine of twelve stations were in the very limited sediment supply category. Based on the review of the statistical analysis, estimates of average background sediment concentrations for the West-side Reservoir watersheds range from 0.6 to 12.7 mg/L with an overall average of 3.5 mg/L. The available data are summarized in Table 3-46

Table 3-46: Average sediment concentrations used to estimate background.

Ranger District	Stream name	Station I.D.	Sediment concentration (mg/l)	Supply Limited?
Spotted Bear R.D.	Whitcomb (lower)	FL4001	4.2	No
	Whitcomb (upper)	FL4005	9.0	No
	Whitcomb (West Fork)	FL4024	12.7	Yes
	Bunker	FL4002	3.0	Yes
	Tin	FL4003	1.7	Yes
	Sullivan	FL4004	4.0	Yes
Hungry Horse R.D.	Emery	FL6001	6.8	Yes
	Logan (South Fork)	FL6002	2.6	Yes
	Wounded Buck (lower)	FL6003	3.8	No
	Wounded Buck (upper)	FL6014	2.6	No
	Wheeler	FL6004	2.2	Yes
	Challenge	FL6005	2.1	No
	Dodge	FL6012	1.7	Yes
	Puzzle	FL6007	1.6	No
	Twenty Five Mile	FL6008	0.6	Yes
	Skyland	FL6009	2.3	No
	Skyland (West Fork)	FL6010	1.6	Yes
	Graves (inlet at reservoir)	FL6016	1.3	Yes

In managed forested areas, the main source of direct sediment is from road construction associated with timber harvest (Megahan and Kidd 1972). Sediment contributions from roads are introduced into stream networks at road – stream (RS) crossings. WEPP – ROAD was used to model several typical RS crossing situations common in the FNF. Eight RS / topography configurations were modeled for typical situations with WEPP-ROAD for the

West Side Reservoir Project and are described in Exhibit G-4. The average sediment leaving the buffer and entering each situational RS crossing was multiplied by the total number of each situational RS crossing to arrive at the tons of sediment introduced directly into the stream networks by roads within watershed groups in the West Side Reservoir Project. The results from WEPP-ROAD are summarized in Table 3-47. Copies of WEPP-ROAD runs are contained in Exhibit G-5.

Changes to Sedimentation in Post-Fire Situations

Soil condition and hydrologic function are important components to healthy ecosystems that are affected by wildfires. A wildfire has the potential to impact the soil by reducing soil aggregate stability, soil permeability, and organic matter/nutrient status. These combined effects may increase runoff following a rain event, increasing the potential for both sheet and rill soil erosion. The potential for erosion is highest on the steeper slopes that burned with a high burn severity.

The term *soil burn severity* is used as a relative measure of fire effects on topsoil and the associated change in watershed conditions. Soil burn severity is delineated on topographic maps of the project area as polygons labeled high, moderate, and low. Soil burn severity describes the effects of the fire on the soil hydrologic function, amount of surface litter, erodibility, infiltration rate, runoff response and productivity. There is generally a close correlation between soil properties and the amount of heat experienced by the soil as well as the residence time of the heat in contact with the soil.

On low severity burn sites the duff layer is typically only partially consumed by the fire and very little heating of the soil surface layer occurs. The fire has not affected the soil hydrologic properties. Many unburned small roots are prevalent immediately below the soil surface, the mineral composition provided a degree of insulation that protected shallow fine roots and embedded seeds. Natural re-vegetation on low burn severity sites is typically very good. The erosion potential can increase with salvage logging if vegetation re-growth is retarded or soils are compacted. The erosion potential decreases over time as the soil surface is re-vegetated and the soil aggregate stability is reestablished. Low burn severity sites will naturally re-vegetate rapidly and have little or no potential for soil erosion.

The moderate burn severity sites tend to show some slight indication of surface soil structure break down and a significant reduction in near surface fine root viability. Some hydrophobic soil conditions may occur under moderate burn severity sites but it is usually quite spotty (Ryan and Noste 1983). Post-fire hydrophobic soil conditions are ameliorated within 2 or 3 weeks under low intensity rain or snow events that slowly wet soil surfaces.

High burn severity sites have surface soil modified by fire. The soil surface structure has been broken down and a hydrophobic (water repellant) layer may have formed during the fire. The surface soil aggregate stability has been significantly reduced. Many soils that once contained moderate to fine granular soil aggregates in the surface layer now contain few intact aggregates and the soil surface is single grain and essentially structureless. The lack of surface soil structure and lack of organic litter or duff allows for rain impact erosion at the soil-air interface, reduced water infiltration and increased runoff and erosion. There are few viable seeds or roots in the upper several inches of the soil and natural revegetation on high burn severity sites is typically very slow.

A study done locally measured the effects of logging and prescribed fire on the soils in the Miller Creek area of the Flathead National Forest (DeByle and Packer 1972). Two or more times the overland flow was reported on the logged and burned plots versus the control plots. Virtually no soil erosion was reported on the control plots but the logged and burned plots produced an average of 56 pounds per acre the first year after treatment and 168 pounds per acre the second year after treatment. Runoff and erosion were attributed to reduced vegetative cover. The organic matter content of the sediment ranged from 12 to 44 % in the treated plots.

Estimation of Post-Fire Sediment Potential from the West-side Reservoir Project Fires

An organic duff layer that ranged in thickness from 1 to 8 inches was supported by the soils of the West-side Reservoir project before the fire. The ash resulting from the fire has been incorporated into the newly formed upper soil layers. The upper soil layers typically contain plant roots, interconnected small pores, and stable soil peds (aggregates) that facilitated rapid water infiltration and percolation. Pre-fire erosion rates were very low to non-existent in undisturbed portions of all watersheds in the project area. Sediment yield increases were modeled with the DISTURBED WEPP interface of the WEPP model.

Surface soil erosion potential for each soil-type within FNF has been modeled with Disturbed WEPP to generate landtype soil erosion factors. The model parameters included the precipitation from the Bigfork weather station to better estimate the high mountain conditions and a 30-year time frame was used to better reflect the 25-year return interval for precipitation conditions causing flood response. The absolute soil erosion factors are constants that are calculated for a given slope condition and must be viewed with some caution due to the wide confidence interval surrounding the values. FNF soil scientists implementing the model found the calculated soil erosion factors to be very reasonable for hill slopes and historic conditions. DISTURBED WEPP is used to arrive at a sediment curve for post-fire landtypes and also for salvage logging on the burned soils. This allows a comparison of the sediment amounts from the entire burned landscape to the burned landscape after salvage logging. R1WATSED provides sediment for undisturbed logged and burned landtypes but has no curve or output for salvage logging on burned landscapes. EXCEL worksheets (Post Fire Erosion WEPP.xls and Salvage Treat WEPP.xls) were developed that generate potential soil erosion in tons/acre for each landtype from the WEPP constants. The landtype sediment delivery factor generated from WATSED was then applied to the soil erosion values to arrive at the potential delivered sediment. Landtypes inside the burn perimeter for each watershed group were input to the EXCEL worksheets to determine potential delivered sediment. This is a reasonable means to provide the effects comparison for logging on burned landscapes. Results are summarized in Table 3-47. Copies of the EXCEL worksheets are contained in Exhibit G-6.

Watersheds containing high percentages of area with moderate to high burn severity are expected to experience an initial flush of ash into streams and the development of rill or small gully erosion in ephemeral drainages on steep valley walls. Under normal precipitation conditions, the majority of slopes in the project area are not expected to experience severe soil erosion. If an intense rainstorm occurred on sites with moderate to high burn severity before post-fire hydrophobic conditions recovered and before natural re-vegetation, there is potential for more than 30 tons per acre of soil erosion to be produced. For a relative measure of soil erosion in tons, one inch of eroded soil material from one acre weighs approximately 200 tons.

Table 3-47: Previous ground disturbing activities, current sediment producing conditions and WEPP modeled sediment yield.

Watershed	Total roads (miles)	Road Density (mile/mile^2)	% Past Timber Activity	BURN SEVERITY (acres)			DISTURBED-WEPP Potential Post-fire Delivered Sediment (Tons)	WEPP – ROAD Estimates (tons) Delivered Sediment
				High or Moderate	Low	Low / Under Burned		
BETA – DORIS FIRES								
Aurora Creek	0.07	0.0	0.8	28.3	0	302.0	31,922	13.8
Betawtrsh1	0.0	0.0	0.0	185.2	0	54.4		
Alpha Creek	2.9	2.5	43.4	44.4	0	299.6		
Beta Creek	3.1	2.5	80.8	185.2	0	54.4		
Betaface	11.4	5.4	84.2	280.1	187.2	784.9		
Mamie Creek	1.7	3.6	43.8	87.9	10.3	197.9		
Doris Creek	15.7	1.2	13.5	559.9	2.6	1456.6		
DOE – BLACKFOOT FIRES								
Wounded Buck	9.1	0.6	10.3	306.6	211.7	3196.9	101,499	34.5
Lost Johnny	9.7	1.0	13.4	81.2	0	579.6		
DoeBlackFace	28.2	5.3	84.1	3.2	14.5	180.0		
Doe Creek	4.2	3.8	52.1	0	0	0.25		
Lid Creek	4.8	1.8	61.3	0	74.0	24.6		
Elya Creek	2.9	3.9	71.6	0	48.8	62.6		
Flossy Creek	4.4	2.7	84.4	118.3	329.7	262.7		
Clayton Creek	11.1	1.7	30.5	446.7	593.6	2955.9		
Goldie Creek	8.7	2.3	41.3	891.1	281.4	945.7		
Blackface	21.4	5.8	70.4	72.8	73.2	300.8		
FannoraNatrona	7.3	5.7	79.7	76.2	0.4	299.3		
Knieff Creek	12.0	2.7	35.3	868.2	125.8	1512.8		
Emma Creek	4.9	5.6	98.4	26.9	0	235.4		
Pearl Creek	3.0	3.0	73.1	242.0	34.9	167.9		
Mazie Creek	5.3	3.7	56.5	0	0.95	11.0		
Ben Creek	6.1	3.5	43.3	7.0	130.5	432.3		
Anna Creek	2.9	4.2	50.9	0	19.4	93.8		
Graves Creek	13.8	0.5	5.6	182.6	268.8	1534.4		
BALL FIRES								
Sullivan Creek	41.1	0.9	11.5	1964.9	116.2	2889.4	79,401	17.8
Quinton Creek	33.7	1.2	14.7	31.4	56.6	788.1		
Ballface	36.4	3.8	59.1	576.6	48.9	822.5		

Nutrient Levels

Information concerning nutrient levels in the Flathead Basin is published in the Joint Water Quality and Quantity Committee Report – Flathead River International Joint Commission Study, (1987). The study states "waters of the Flathead River system contain very low amounts of the major nutrients, nitrogen and phosphorus. Autotrophic production in most lotic and lentic waters in the basin appear to be phosphorous limited, although nitrogen may not be present in sufficient quantity or in required forms to support much productivity during late summer in some waters" (Stanford, 1987). The relationship between suspended sediment and nitrogen and phosphorus concentrations was addressed and a significant, positive correlation between suspended sediment solids and total phosphorus (TP) and total Kjeldahl nitrogen (TKN) on the Flathead River directly upstream from the confluence with Flathead Lake was reported. The soluble phosphorus compounds (SP: soluble phosphorus and SRP: soluble reactive phosphorus) are leached or desorbed from particles suspended in the water column or flushed from groundwater. The study also described the relationship between total phosphorous and biologically available phosphorous: "bioavailability was estimated by a kinetic approach, using radioactive tracers, and by algal assays. Both methods demonstrated that only about 10% of the sediment particulate phosphorus (total phosphorus minus soluble phosphorous) was bioavailable. The rivers in the Flathead Basin carry a substantial load of biologically inert phosphorus during spring runoff" (Ellis and Stanford 1986a, b, c).

Nutrient Responses in Post Fire Situations

When a fire burns through down fuels, oxidation releases many elements to become available for leaching and/or aerial deposition into running or standing surface water. Nutrients can also be transported into streams, ionically attached to soil particles associated with increased post-fire erosion. The low burn severity sites have virtually no effect on the soil's physical or chemical properties. During the burning process some nutrients in the grass and duff are released into the atmosphere; however most remain in the ash and are rapidly reabsorbed into the topsoil. (DeByle 1981) Soils directly under areas of concentrated woody fuels can be heated enough to cause a slight reduction of some soil nutrients (e.g. nitrogen) and microbe populations in the surface soil layer. There is a short-term (2-3 year) reduction in vegetation cover on these sites following the fire, which in turn lead to small amounts of surface soil erosion. The eroded soil material is rarely transported more than a few feet downhill. There are minimal short-term, widely spaced (<5% estimated area) reductions in site productivity in units following the burn. In the same study, an increased potential for soil nutrient leaching into the groundwater on high burn severity sites during major precipitation events was documented. (Packer, Williams 1976).

Within the Flathead Basin the primary nutrients of concern that have been identified and studied, in relationship to timber harvest and fire activities, are phosphorus and nitrogen. Hungry Horse Reservoir acts as a sediment sink for all drainages above the dam. The nutrients attached to sediment are trapped at Hungry Horse dam and would not pose any threat of increased nutrient loading from the West-side Reservoir fires into Flathead Lake.

The heat of the wildfire also affects the nutrient status of some of the soils. The soils that experienced high burn severity are generally the most affected. These soils are most susceptible to nutrient loss by either: 1) volatilization during the fire, 2) potential post-fire soil erosion, and 3) loss by leaching. There is expected significant increase in nutrients (nitrogen and phosphorus) delivered from the fire area, into streams or directly into the reservoir. The nutrient increase should not pose a problem for aquatic systems within the reservoir due to the volume of water contained within the reservoir and the constant input of fresh water from the South Fork River. Expected nitrogen and phosphorus yields for each common landtype after fire are estimated and displayed in Table 3-48.

Environmental Consequences

Two aspects of the water resource are vulnerable to either natural disturbance (i.e. wildfire) or to man's activities (i.e. timber salvage): water quantity and water quality. Water quantity or water yield increases from a watershed are a direct consequence of wildfire in a forested environment. The next section discusses in more detail the water yield increases that are attributable to fire.

Water quality is characterized by the chemical and physical properties of the water. Two primary effects to water quality from wildfire and post-fire salvage are the potential for increased nutrient content in groundwater or surface water (chemical), and increased sediment (physical). The next section discusses in more detail the minor nutrient increases from salvaging dead trees as compared to the nutrient effects of the wildfire. The primary measurable effect to water quality of the proposed salvage harvest and the road treatments are an increase in sediment. Therefore the following *Effects Indicators* were used to focus the analysis and disclose relevant environmental effects of the proposed actions in Alternatives B thru E:

- Potential sediment from proposed salvage harvest (tons);
- Road decommissioning: number of culverts removed and the resulting potential short-term sediment yield increase (tons)
- Road Best Management Practices (BMPs) installation: potential short-term sediment produced during installation and potential long-term reduction in sediment yield.

Herein is a discussion of the effects of wildfire and the proposed activities (salvage harvest and road treatments) on water quantity and water quality within the West-side Reservoir Project area.

Water Quantity

Water Yield Increase

R1WATSED was used to model water yield increase in each of the analysis watershed groups (refer to Table 3-44: Water Yield for analysis watersheds…). The existing post-fire condition was modeled using a combination of the acreages of the unburned natural forest stands, the unburned stands with some type of timber management (i.e. percent crown removal), the burned natural and managed stands, and the miles of existing roads. The analysis watersheds that were either partly or entirely burned during the Blackfoot Complex Fires have an estimated annual water yield increase directly due to wildfire that ranges from 0.1 to 26%.

R1WATSED was used to analyze any possible effect to water yield increase due to the proposed salvage in Alternatives B through E. The acreage of a proposed salvage unit was subtracted from the burned acreage in the same watershed in order not to double account for the removal of the vegetation and the acreage. The results of the annual water yield increase with the implementation of each alternative were compared to the post-fire annual water yield increase for each of the analysis watershed groups. The existing annual water yield increase was reduced by the time the proposed salvage would be implemented under all alternatives due to soil and vegetation recovery, and there was no water yield increase due to the proposed salvage harvest. No increase in annual water yield is associated with the proposed salvage activity due to:

- There is no change in the amount of live canopy remaining from the fire-killed forest to a post-fire salvage harvest unit. Note for the purposes of the water yield modeling, 100 percent of the crown cover was assumed to be removed in the high and moderate burned forest stands, 50 percent of the crown cover was assumed to be removed in the low burned forest stands and 35 percent of the crown cover was assumed to be removed in the low/unburned forest stands. This assumption was based upon extensive walk-thru field reviews (fall 2003 and in past salvage sale projects, Moose 2002) of the burned stands by silviculturists and the hydrologist.
- A minimum year to year and a half (2 growing seasons) vegetative recovery will occur from the time of the wildfire to the approximate time of the majority of the proposed salvage. Even that very slight vegetation recovery reduces the modeled water yield increase. By the estimated time of implementation of the proposed salvage in all alternatives, a reduction in the water yield increase of <1 to 4 % in each of the analysis watershed groups occurs due to vegetation recovery. See the Project File for R1WATSED model results.

Water yield increases from proposed salvage

The fire effects on percent water yield increase for the analysis watershed groups have been individually presented in Table 3-44 and are summarized below in Table 3-49. The results of the R1WATSED modeling for the proposed salvage units indicate no additional increase in water yield can be directly attributed to salvage of dead trees.

Table 3-49: Summarization of RIWATSED modeled Fire Effects

	Post – Fire Estimated Water Yield Increase (%)
Beta – Doris Fires	57.5
Doe – Blackfoot Fires	112.8
Ball Fires	5.0
TOTALS	**175.3**

Watersheds with moderate or high vegetation burn intensities and watersheds with moderate or high soil burn severity are the watersheds with the most potential for water yield increases. The increase in water yield has the most potential to cause short-term increases in channel erosion in several of the small 1st order streams in the West-side Reservoir Project due to the combination of burning of the riparian vegetation, and in some cases burning large woody debris within the stream banks, along with the naturally erodible stream bank materials.

The field review of stream channels in the project area verified that the streams potentially affected by the proposed salvage timber harvest are in Good or Fair Pfankuch stream stability rating classes. Channels in the Good class are capable of handling more water yield increase with no major adverse effects. The channels in the Fair class are at increased risk of channel erosion from the additional water yield. Refer to Table 3-41: Summarization of Stream Channel Surveys.

Water Yield - Rain on Snow (ROS) Event Risk

Rain on Snow Events is a concern brought forth by several interested publics on similar projects in the past; therefore a discussion is included herein.

Mac Donald and Hoffman (1995) discussed the causes of peak flow ROS and rain-on-spring-snowmelt events in six basins of Northwestern Montana and Northeastern Idaho and concluded, "… There was no apparent correlation between the magnitude of peak flows and the amount of forest harvest." In 1996, the Plum Creek Timber Company employed a consultant to model ROS events in the Swan River Valley. The basins modeled were Goat and Squeezer Creeks. The analysis estimated a 4.9% increase in runoff from a ROS event for a 25-year return interval storm, and 4.5% increase for a 100-year return interval storm. The modeled increased runoffs are the amount of increase above the level for a fully forested situation versus the current forested situation for Goat and Squeezer Creeks. (Plum Creek, 1997) The amount and type of timber harvest in the lower elevations of Goat and Squeezer Creeks are qualitatively similar to the amount of harvest in the lower elevation portions of Sullivan, Quintonkin and the Ball "face" drainages prior to the wildfire. Because of the reduction in canopy cover from the effects of the wildfire there is potential for increased snow deposition. Based upon the wildfire effects to the vegetation there would be an increase in the effects of a ROS event in the Ball Fire area. The combination of the wildfire effects to the vegetation, and the slight increase in snow deposition due to post-fire timber salvage would be an increase in the effects of a ROS event in Ball Fire area. The proposed salvage harvesting may result in a minor portion of that increased risk, but it would contribute slightly to increased peak flow if a ROS event were to occur in the next few years until some significant forest regeneration growth has occurred. The additional peak flow increase could have a risk of increasing the amount of channel erosion during a typical ROS event in the project area. The records (1964 – 1997) for the USGS flow gage at Twin Creek, station I.D. 12359800, above Hungry Horse Reservoir were reviewed for peak flow events. One peak flow event occurred November 11, 1989, which was not a ROS event. Another occurred April 24, 1969, which may have been ROS even if earlier than the normal spring melt period. The records (1948 – 1976) for the USGS flow gage at Sullivan Creek, station I.D. 12361000, exhibited a normal spring snowmelt period of May through June. One peak flow event occurred on January 16, 1974 that may have been ROS. Stations in the South Fork of the Flathead have recorded approximately two ROS events during a 50-year period of record, therefore the chance that salvage logging may aggravate peak flow ROS events is unlikely.

The water yield effects to peak flows for watersheds in the Beta-Doris and Doe-Blackfoot analysis areas is expected to be less than the Mac Donald and Hoffman (1995) and the Plum Creek (1997) studies due to the fact that most of the lower elevation portions of those drainages are under Hungry Horse Reservoir.

Water Quality

Nutrient Effects

As discussed in Chapter 3: Nutrient Responses in Post Fire Situations, the background nutrient response for all alternatives will be dependent on burn severity experienced within salvage units on various landforms. One of the past actions, aerial fire retardant drops, discussed in following sections, has the potential to effect nutrient response in the first run-off season. Norris and Webb (1989) report that when retardant is applied outside the riparian zone there is a minimal long-term effect to water quality.

Debano et al. (1998) reports that several investigations following wildfire have found little effect of burning on ionic cation concentrations in run-off waters. At the same time he reports that other investigators have observed increased cation concentrations in stream flow following a wildfire. Typically, cations such as Ca, Mg, and K are converted into oxides, and are deposited as ash following a wildfire. These oxides are low in solubility until they react with CO_2 and are converted into bicarbonate salt (Debano et al. 1998). The surface soils in the Flathead NF are typically derived from volcanic ash. They tend to have a very high cation exchange capacity, and are naturally low in levels of bicarbonate (Martinson and Basko 1983). Therefore, the potential for cation leaching into ground or surface waters following the fire is probably low unless a major erosion event occurs.

Within the Flathead Basin, phosphorus and nitrogen are the primary nutrients of concern that have been identified and studied in connection to timber harvest and fire activities. In the Flathead Basin the primary concern with any nutrient increase in the headwater streams is a potential for increasing the nutrient levels in Flathead Lake, which will lead to increased algae growth in the lake. This was specifically addressed in the Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana (Montana Department of Environmental Quality, 2001), which identifies phosphorus and nitrogen as the primary nutrients of concern in the Flathead Lake basin. Hungry Horse Reservoir acts as a sink for nutrients and will dilute and contain nutrient responses from streams that end in the Reservoir. For the drainages on the Beta – Doris Fire (Aurora/Fawn and Beta1) that empty directly into the South Fork River below Hungry Horse Dam, the nutrient flush should be diluted after the first run-off season.

Increased nutrient loading associated with wildfire can stimulate primary production (e.g. algae growth). Hauer and Spenser (1998), and Gangemi (1991) described an increase in stream periphyton growth in one burned watershed in the Red Bench Fire area, compared to an unburned watershed. Hauer and Spenser (1998) reported "we did not observe noticeable increases in algae growth in our larger 3rd and 4th order study streams."

The level of nutrient in groundwater and surface water of the West-side Reservoir Project streams will increase from pre-fire base levels to an elevated level due to the fires. Hauer and Spencer (1998) reported that the highest levels of nutrient increase correlated to those areas with high burn severity. In watersheds with less than 50% burned, nutrient increases caused by the fire should be on the lower portion of Hauer and Spenser's reported ranges for soluble reactive phosphorus (SRP) and nitrate increases. The effect of increased sedimentation and slightly decreased ground cover due to the salvage logging may cause a slight increase in the level of nutrients of concern (phosphorus and nitrogen). The primary change within a salvage unit is to increase the amount of smaller, fine limbs and trunks in direct contact with the ground, enhancing the potential for nutrient leaching.

The increase in nutrient levels due to the salvage logging would be small compared to the increase caused by the wildfire. This conclusion is based on the following rationale:

- Some biomass (stems and treetops) will be removed by slash treatments, lowering the nutrient contribution from the unit as a whole;
- Smaller limbs, twigs, and needles are the portions of a tree that contain the most readily releasable nutrients (Page-Dumroese et al. 1991) and most have already been partially or totally consumed by the wildfire;
- Salvage logging will not significantly change the chemical or hydrophobic characteristics of the post-fire soils;
- Over time, the natural process of blow down after a wildfire increases the amount of limbs on the ground;
- The increase in sedimentation (conduit of nutrients) due to salvage harvest is relatively small compared to the increased erosion/sedimentation caused by the wildfire.

The potential for leaching soil nutrients into groundwater is slightly increased for the first 2 or 3 years following wildfire. Leaching probability is reduced significantly in soils with high cation exchange capacity and moderately well drained soil permeability characteristics. The majority of soils in the proposed units are derived from glacial till with those characteristics. Some soils in valley bottom landtypes have excessively drained subsoil and have a slightly greater risk of leaching nutrients directly into groundwater, even though the topsoil has a high cation exchange. The soil types with high soil burn severity are the most susceptible to excess leaching following fire.

Dust abatement using calcium chloride or magnesium chloride solutions rather than water may introduce small amounts of those chemicals into the stream system. Typically, these solutions ionically bond to the soil materials in the road surface and are very slowly weathered/leached from the road surface into the surrounding soils over a 3 – 5 year time period. These chemicals would be immeasurable versus natural background amounts of calcium, magnesium, and chloride in the water if they were to reach project area streams.

The overall increase in nutrient levels associated with the proposed salvage activities should not be measurable above natural variation once West-side Reservoir Project watersheds combine with the waters contained in the Hungry Horse Reservoir.

Sediment Yield Increase Due to Salvage Harvest

In managed forested areas, the main source of sediment directly input to stream networks is from road construction associated with timber harvest (Megahan and Kidd 1972). Channel alteration, road or other construction in or adjacent to flowing streams, and culvert or bridge installation may result in sediment being deposited directly into a stream. Tree falling is not usually considered a major cause of increased sediment. However, methods for removing harvested timber (such as tractor and cable yarding) can cause erosion, due to reduced vegetative cover and altered soil characteristics such as soil permeability. The extent to which logging exacerbates soil, sediment, and hydrologic problems in post-fire landscapes will depend on site characteristic, site preparations, logging method and whether new roads are needed. Road building and continued use of existing roads are probably the biggest potential contributors to post-fire erosion, just as in green tree stands (Megahan, 1980).

Site characteristics generally have a profound influence on whether significant sediment is produced by a logging operation. The WRENS model described by Potts and others (1985) suggests that both sediment and water yields increase with catchment area and slope in logged post-fire landscapes. The effect of post-fire logging on sediment production also depends on logging system type and the extent to which logging residue remains on a site.

A wildfire has the potential to impact the soil, including reduced soil aggregate stability, reduced permeability, and reduced organic matter and nutrient status. The combined effects will increase runoff following a rain event, significantly increasing the potential for both sheet and rill types of soil erosion. The potential for erosion is highest on the steeper slopes that burned with a high burn severity. The burned areas for the analysis watersheds were input to an EXCEL worksheet that incorporates the Disturbed WEPP coefficients for potential hillslope erosion for each land type with the R1WATSED sediment delivery coefficient. The worksheet estimates the amount of material that potentially moves down slope to a stream channel where it could potentially become sediment. Unit size, land type, and harvest method were parameters input to the EXCEL worksheet to estimate the sediment yield from wildfire. Copies of the worksheets are included in the Exhibit G-7. The historic ground disturbing activities (road building associated with timber management), current sediment producing conditions and DISTURBED WEPP modeled estimates for post-fire delivered sediment have been discussed previously and are presented again here in Table 3-50. The estimated post-fire naturally delivered sediment represents the amount of eroded material that could potentially reach stream channels based on the burned acres of each land type. Logging (helicopter, cable, ground) on proposed units in all action alternatives could begin during the winter of 2005 and may extend through 2006. Re-vegetation on burned acres will have two growing seasons to recovery. Vegetation recovery will reduce the amount of delivered sediment to stream channels. Road management in association with the various salvage logging proposals is the determinate factor for estimating sediment yield from the action alternatives.

Table 3-50: Summarization of DISTURBED WEPP modeled fire effects.

	Post-Fire Estimated Naturally Delivered Sediment (tons)	Post-Fire Estimated Existing Road Delivered Sediment (tons)
Beta – Doris Fires	31,922	13.8
Doe – Blackfoot Fires	101,499	34.5
Ball Fires	79,401	17.8
TOTALS	212,822	66.1

The salvage logging in all action alternatives will require helicopter landings to extract logs from proposed units. Each landing would be approximately 1 to 1.5 acres in size and exact locations are not known at publication of the DEIS. To estimate sediment produced from landing construction associated with salvage logging for the action alternatives, the following assumptions were made and input through WEPP-ROAD:

- Size for calculation purposes is set at 1.25 acres (54,450 square feet);
- Landing construction entails widening an existing road at an appropriate location and slope to enable transport trucks access and load ability;
- High traffic volume during actually logging operations;
- Outsloped and rutted, native road surface of silt loam with 10% rock fragments;
- Fill is 15 feet long with a gradient set at 45% for calculation purposes (mean of West-side Reservoir terrain);
- Buffer is 200 feet deep with a gradient set at 25% for calculation purposes;
- Landing slope for calculation purposes is set at 8%.

The sediment fact obtained (168 pounds/year) with the assumptions above was multiplied by the number of landings for each action alternative to estimate sediment produced from landing construction and utilization. The WEPP-ROAD results are included in the Exhibit G-8.

Sediment Yield Increase or Decrease Due to Road Management

The West Side Reservoir Post-fire Project Draft EIS proposes to change the road management scenario on some of the roads within the project area. The different road management categories that are proposed in the Draft EIS are the following:

- Restrict the seasons of use,
- Close the road yearlong with a gate,
- Close the road yearlong with a berm,
- Decommissioning the road.

Each of these road management categories affects water quality and water quantity in a slightly different way.

Roads that are gated and open seasonally may have increased or decreased sedimentation potential when compared to a season long open road. The seasonally closed road surface is exposed to the same rain and snowmelt events to erode the surface as a yearlong open road. The amount of sedimentation depends on the drainage structures built into the road prism and the amount of maintenance the road surface and the drainage structures receive. When roads are used but not graded, rutting occurs, which can concentrate water flow causing increased road surface erosion and sedimentation. Seasonally open roads receive less maintenance than roads open yearlong and therefore, would have a slightly higher potential for sedimentation. Roads that are open yearlong and receive heavy use and regular road grading can have higher sediment yields because of the input of sediment following grading, especially when the ditches are cleared out with a grader. This road management scenario easily allows for periodic inspection and maintenance of culverts, ditches, and cross-drain culverts, which reduces the risk of culvert plugging or culvert failures and associated sedimentation potential and does not change the water quantity delivered to a stream from the road system.

Some re-vegetation of the roadbed occurs with grass and brush species when a road is restricted year long with a gate. The amount of the re-vegetation on the roadbed is determined by the amount of administrative road use, the type of vegetation on the site, and the soil moisture conditions in that locale. This road use category results in less erosion from the road surface and ditches. Occasionally when this category of road is used for administrative purposes rutting can occur and if not maintained, then increased sedimentation can result from this gated yearlong road situation. This road management category easily allows for periodic inspection and maintenance of culverts ditches, and cross-drain culverts, which reduces the risk of culvert plugging or culvert failures and associated sedimentation potential and does not change the water quantity delivered to a stream from the road system.

When a road is restricted yearlong with a berm, the culverts may or may not be removed depending on whether or not the road is to remain on the FNF road system, and if any high risk culverts (prone to plugging or failure) are present. If a road is to remain on the road system there are no culverts removed unless a high-risk culvert is identified. This scenario allows for the monitoring and inspection of remaining culverts; however, both the monitoring and the mechanical maintenance of these culverts are made more difficult and expensive with a berm in place. Therefore, the long-term risk of culvert plugging or culvert failure and the associated sedimentation potential is increased as compared to the road management category utilizing gates. Once the road is bermed the roadbed is allowed to re-vegetate and the potential road prism soil erosion and sedimentation is significantly reduced. The road closed yearlong with a berm management category does not change the water quantity delivered to a stream from the road system.

Road decommissioning includes the following:

- The road surface has water bars installed to decrease water concentration and movement that causes soil erosion from the road surface;
- The removal of all culverts at perennial and intermittent stream crossings to eliminate the possibly of a culvert failure;
- The seeding of all or portions (depending on soil type and natural vegetation type) of the roadbed to initiate re-vegetation and reduce soil erosion;
- Grass seeding and erosion control matting or straw mulch is installed at each excavated steam crossing; and
- At stream crossing excavation sites the planting of shrubs is done to speed up re-vegetation where deemed necessary.

The decommissioned road category reduces the long-term potential for direct road associated soil erosion and sedimentation better than the other road management categories. (Kootenai National Forest, 1995) There are three direct effects of road decommissioning:

- A short-term (usually <4 hours) sediment input during the actual removal of a culvert, as the fine sediments in the bottom of the streambed under the culvert are washed downstream until the streambed becomes naturally armored;
- With the first spring peak flow event following the decommissioning, some erosion of the lower stream banks in the stream channel at the removal site will occur. The short-term potential increase in sediment varies with the soil materials and the hillslope at the culvert site. Steep slopes result in more exposed soil from which erosion can occur. The less the coarse fragment content, and the finer the soil texture, the more potential for soil erosion.
- The amount of ditch-intercepted groundwater delivered to the stream is dramatically reduced during the decommissioning process due to installation of water bars with ditch blocks to intercept road-surface and ditch runoff. Only very short ditch sections directly above stream crossings continue to funnel ditch water into the stream after water bars are installed. Decreasing the amount of ditch-intercepted groundwater decreases the amount of water that reaches the stream channels during peak flow events (e.g. spring snow-melt); therefore, with less water flowing in the channel there is less *stream power* to cause stream bank erosion.

Timing of culvert removals and application of Best Management Practises (BMPs) can minimize the effects of road decommissioning activities. Staggering culvert removals over more than one season in a single watershed reduces the amount of sediment entering a stream at any given season. Following a culvert removal, the use of erosion control matting and shrub planting for streambank stabilization further reduces additional erosion and sedimentation.

An analysis was done to estimate the possible effects from culvert removals in comparison to the effects of a culvert becoming plugged and a portion of the road prism eroding. The depth of roadbed over the top of a culvert is directly proportional to the slope of the streambed at the installation site. The steeper the installation site, the more surface area exposed to erosion with either a culvert removal or a culvert failure. For this comparison, three culvert installation scenarios were analyzed;

- On nearly level ground;
- On very steep hillslope; and
- On a typical moderate hillslope.

Actual field measurements of culvert installations and many erosion monitoring observation measurements were used in the calculations. Three different scenarios were analyzed:

- Culvert removal in non-erosive soil conditions, with all best management practices applied;
- Culvert removal in erosive soil conditions, with limited best management practices applied;

- Culvert is plugged and the road prism directly above a culvert is eroded downstream.

The surface area exposed for each scenario was calculated and then multiplied by the erosion depth to obtain an estimated volume of eroded material, with the following assumptions:

- The volume of eroded material in the typical glacial till soils of this area would yield approximately 60 percent suspended sediment and 40 percent bed load sediments;
- The scenario representing erosion caused by a plugged culvert is conservative because none of the stream bank erosion that typically occurs directly below a failed culvert was modeled; only the volume of soil materials in the eroded road prism directly over the culvert was considered. Stream bank erosion in these situations is extremely variable depending on site characteristics, for that reason it was not modeled;
- When a culvert becomes plugged, the water may go down the road some distance before eroding the road fill-slope. This extremely variable situation was not modeled for that reason. Refer to Table 3-51 for the comparison of the total volume of eroded soil material for each scenario.

To estimate the number of culvert removals during road decommissioning for each alternative, all available road surveys, mapped roads and streams, and FNF library GIS layers were used. Some additional culvert removals may be needed if ephemeral streams not currently mapped are encountered. The estimated number of removals will be verified between the draft and final EIS. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform, slope, and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion or sediment yield from Table 3-51 was assumed for all the removal sites in the project area, because of soil types present on the West-side Reservoir proposed projects.

Table 3-51. A Comparison of Total Weight/Volume of Eroded Soil Materials from a Culvert Removal Site versus a Culvert Failure and the Associated Road Prism Erosion.

Culvert Depth[1]	Culvert Removal Best Case Scenario For Soil Erosion	Culvert Removal Worst Case Scenario For Soil Erosion	Culvert Plugged the Road Prism Above the Culvert is Eroded Away
Shallow Depth (4.1 ft.)	4.6 tons (3.1 cu. yds.)	11.0 tons (8.1 cu. yds.)	7.4 tons (5.0 cu. yds.)
Moderate Depth (6.3 ft.)	4.4 tons (2.9 cu. yds.)	13.5 tons (9.1 cu. yds.)	17.2 tons (11.5 cu. yds.)
Deep Depth (15.8 ft.)	12.5 tons (8.4 cu. yds.)	50.7 tons (34.1 cu. yds.)	202.4 tons (136.3 cu. yds.)

[1]Depth is measured from the top of the outside shoulder of the road, vertically to the bottom of the culvert.

Beschta Report

Several public comments referred to a report by a group of aquatic scientists from the northwest with recommendations on wildfire and salvage logging, referred to as "The Beschta Report." Many of their recommendations are applicable to the West-side Reservoir Project. Most of the concerns identified in the Beschta *et al.* (1995) report are addressed in the design of the various alternatives (e.g. helicopter logging, RCHA width, road decommissioning), special design features (e.g. soil skid trail requirements), or implementation of Montana Forestry Best Management Practice and The Montana Streamside Management Zone law requirements.

Direct and Indirect Effects

Alternative A – No Action

There are no direct effects from road management activities to the water resources in the post fire project area if Alternative A, the No Action alternative is implemented. No ground disturbing activities would be implemented with this alternative; therefore no direct effect to the water quantity or quality occurs from a direct federal action.

The effects of the wildfire to sediment yield increases, water yield increases and nutrient increases have been described and discussed in previous sections. Alternative A, no action, would not change the wildfire effects to those parameters of water quality and water quantity.

There are two possible indirect effects to the water resource of the area if Alternative A is implemented. The long-term decrease in the sediment yield would be foregone if the road decommissioning proposed in Alternatives B thru E were not implemented. The risk of culvert failures would significantly increase without the road decommissioning proposed in Alternative B thru E.

Alternative B

Sediment from proposed salvage

Using the DISTURBED WEPP interface of the soil erosion model, the potential soil erosion and then R1WATSED delivered sediment yield was modeled for the proposed salvage units in Alternative B. The increased soil erosion associated with yarding of the salvage logs is due to a reduction in the post-fire vegetation cover due to skidding of the logs across the ground. The amount of disturbed ground and vegetation removal is greatest with ground skidding, less with skyline yarding, and the least with helicopter yarding. The modeled potential sediment increase from the Alternative B proposed salvage logging is 234 tons, from the 4921 acres of proposed salvage with 52 landings. The potential sediment increase associated with the proposed salvage logging within the Beta-Doris Fire area is approximately 0.26% of the potential sediment delivered during possible major storm events the first year after wildfire, when the soils are most susceptible to soil erosion. From the Doe – Blackfoot Fire area the additional sediment delivered to stream channels with salvage logging treatments is 0.09% of the potential sediment delivered after wildfire. Salvage logging on the Ball Fire area will increase the sediment delivered to stream channels by 0.07%. The estimated amount of potential sediment increase from the proposed salvage logging is within the range of natural variability of the sediment yields for the streams within the project area. Any sediment that would eventually reach stream channels will be flushed through the system within the first or second run-off seasons, dependent on snow pack accumulations and spring runoff events.

For the entire West-side Reservoir Project salvage sales for Alternative B, the additional sediment potentially delivered to stream channels increases by 0.11% from naturally delivered sediment due to the wildfire. The comparisons between estimated naturally delivered sediment resulting from the wildfire and additional sediment delivered from the proposed salvage including construction of helicopter landings with Alternative B are summarized in Table 3-52.

Table 3-52: Alternative B potential delivered sediment with and without salvage treatment.

	Post – Fire Estimated Naturally Delivered Sediment (tons)	Alternative B: Potential Additional Delivered Sediment with Salvage (tons)
Beta – Doris Fires	31,922	83
Doe – Blackfoot Fires	101,499	93
Ball Fires	79,401	53
52 Helicopter Landings	0	5
TOTALS	212,822	234

Road Management

With the implementation of Alternative B, there would be 29 miles of road currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned.

Alternative B proposes 49 miles of road decommissioning. There are net long-term positive effects to water quality and water quantity when a road is decommissioned. The positive effect to water quantity and quality would be the reduced road surface area and reduced ditch lengths contributing runoff water and eroded soil particles as suspended sediment to the stream networks accomplished when water bars are installed on the decommissioned road. The other positive long-term effect to water quality is the reduction in the risk of culvert failure, and the associated sediment with that event. Road decommissioning is estimated to involve 42 culvert removals in perennial and ephemeral streams for Alternative B. See Table 3-53 for the estimated sediment associated with these culvert removals.

In Alternative B, there are 23 miles of road proposed to be open seasonally, which is 10 miles more than currently exists. As discussed earlier, roads open seasonally get less maintenance than roads open yearlong which typically results in slightly higher road surface erosion. Therefore, a 10-mile increase in the open seasonally road mileage would have a slight negative effect to water quality. There would not be a change to the water quantity situation.

In Alternative B, there are 58 fewer miles of road closed yearlong with a gate than the existing road access situation. The majority of those miles are being converted to decommissioned roads under Alternative B. The effect of this road management change would be to decrease the water quantity delivered to stream networks from the road system. After the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process.

Table 3-53: Estimated number of culvert removals associated with the Alternative B proposed road decommissioning and the related potential sediment yield from this activity.

Culvert Removals (Depth)		Potential Sediment Yield (Tons)
Shallow	4	18.4
Moderate	11	48.4
Deep	27	337.5
Totals	**42**	**404.3**

The other category of road management that increases in mileage under Alternative B is the restricted yearlong with a berm class. In Alternative B, there are 85 miles of road proposed to be restricted yearlong with a berm, which is 36 miles more than currently exists. Restricting roads yearlong with a berm greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. The roadbed would re-vegetate at some point in time, making the road impassable to machinery unless removal of the brush takes place. Therefore, the long-term risk for culvert failure and associated sedimentation is increased. The volume of eroded material from a plugged culvert or culvert failure can be very significant. Under Alternative B there are 4 miles of roads currently closed yearlong that are proposed for log hauling during the salvage operations and are referred to as "temporary road construction". During the logging operation any natural re-vegetation left by the fires would be removed from the road surface, thus slightly increasing the amount of potential sedimentation from those roads for several years. These roads would be closed yearlong with a berm at completion of salvage operations.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning unless a culvert is identified as having a high risk of failure. If a culvert were identified as high risk, one of three actions would occur:

- High-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity;
- The high-risk culvert would be removed if maintenance problems were not created beyond the removal site.
- The majority of the fill over a culvert would be removed and the overlying road surface would be rock-armored to minimize erosion if the pipe should become plugged.

If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure. This road management category allows the road surface to re-vegetate, which significantly reduces mid-term and long-term sedimentation.

Under Alternative B there are 43 miles fewer motorized trails. The motorized trails are being converted to non-motorized trails. The erosion potential from those trails would be reduced slightly, as compared to when the trails were motorized.

Under Alternative B there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in the project area watersheds. Therefore Alternative B has a long-term positive effect on the sediment load (39.9 tons annual reduction), as compared to the no-action Alternative A. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative B is 404.3 tons.

Alternative C

Sediment from proposed salvage

The modeled potential sediment increase from the Alternative C proposed salvage logging is 182 tons, from the 3949 acres of proposed salvage with 47 landings. The additional delivered sediment to stream channels within the Beta-Doris Fire area with the salvage logging treatments is 0.21% of the potential sediment delivered from wildfire. From the Doe – Blackfoot Fire area the additional sediment delivered to stream channels with salvage logging treatments is 0.08% of the potential sediment delivered from wildfire. Salvage logging on the Ball Fire area will increase the sediment delivered to stream channels by 0.04%. The estimated amount of potential sediment increase from the proposed salvage logging is within the range of natural variability of the sediment yields for the streams within the project area. Any sediment that would eventually reach stream channels will be flushed through the system within the first or second run-off seasons, dependent on snow pack accumulations and spring runoff events.

For the entire West-side Reservoir Project salvage sales for Alternative C, the additional sediment potentially delivered to stream channels increases by 0.09% from naturally delivered sediment due to the wildfire. The comparisons between estimated naturally delivered sediment resulting from the wildfire and additional sediment delivered from the proposed salvage including construction of helicopter landings with Alternative C are summarized in Table 3-54.

Table 3-54: Alternative C potential delivered sediment with and without salvage treatment.

	Post – Fire Potential Naturally Delivered Sediment (tons)	Alternative C: Potential Additional Delivered Sediment with Salvage (tons)
Beta – Doris Fires	31,922	67
Doe – Blackfoot Fires	101,499	78
Ball Fires	79,401	33
47 Helicopter Landings	0	4
TOTALS	212,822	182

Road Management

With the implementation of Alternative C, there would be 36 miles of road that is currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned.

Alternative C proposes 69 miles of road decommissioning. Road decommissioning is estimated to involve 43 culvert removals in perennial and ephemeral streams for Alternative C. Some additional culvert removals may be needed if ephemeral streams not currently mapped are encountered. See Table 3-55 for the estimated sediment associated with these culvert removals.

Table 3-55: Estimated number of culvert removals associated with the Alternative C proposed road decommissioning and the related sediment yield from this activity.

Culvert Removals (Depth)		Sediment Yield (Tons)
Shallow	4	18.4
Moderate	10	44.0
Deep	29	362.5
Totals	**43**	**424.9**

In Alternative C, there are 11 miles of road proposed to be open seasonally, which is 2 miles fewer than exist currently. These two miles are being converted into closed yearlong with a berm status. As discussed earlier, roads closed yearlong with a berm have more natural re-vegetation on the road surface that slightly decreases the potential soil erosion. Therefore, a 2 mile decrease in the open seasonally road mileage would have a slight positive effect to water quality. There would not be a change to the water quantity situation.

In Alternative C, there are 52 fewer miles of road closed yearlong with a gate than the existing road access situation. The majority of those miles are being converted to decommissioned roads under Alternative C. The effect of this road management would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction in comparison to roads gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process.

The other category of road management that increases in mileage under Alternative C is the restricted yearlong with a berm category. In Alternative C, there are 78 miles of road proposed to be restricted yearlong with a berm, which is 29 miles more than currently exists. Under Alternative C there are 4 miles of roads currently closed yearlong and re-vegetated that are proposed for log hauling during the salvage operations and are referred to as “temporary road construction”. During the logging operation any natural re-vegetation would be removed from the road surface, thus slightly increasing the amount of potential sedimentation from those roads for several years. These roads would be closed yearlong with a berm at completion of salvage operations.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning unless a culvert is identified as having a high risk of failure. If a culvert were identified as high risk one of three actions would occur:

- High-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity;
- The high-risk culvert would be removed if maintenance problems were not created beyond the removal site.
- The majority of the fill over a culvert would be removed and the overlying road surface would be rock-armored to minimize erosion if the pipe should become plugged

If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure. This road management category allows the road surface to re-vegetate, which significantly reduces mid-term and long-term sedimentation.

Under Alternative C there are 60 miles fewer motorized trails. The motorized trails are being converted to non-motorized trails. This would reduce the erosion/sedimentation potential from those trails slightly, as compared to when the trails were motorized.

Under Alternative C there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in the project area watersheds. Alternative C has a long-term positive effect on the sediment load (39.8 tons annual reduction), as compared to the no-action Alternative A. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative C is 424.9 tons.

Alternative D

Sediment from proposed salvage

The modeled potential sediment increase from the Alternative D proposed salvage logging is 234 tons, from the 5298 acres of proposed salvage with 52 landings. The additional delivered sediment to stream channels within the Beta-Doris Fire area with the salvage logging treatments is 0.26% of the potential sediment delivered from wildfire. From the Doe – Blackfoot Fire area the additional sediment delivered to stream channels with salvage logging treatments is 0.09% of the potential sediment delivered from wildfire. Salvage logging on the Ball Fire area will increase the sediment delivered to stream channels by 0.07%. The estimated amount of potential sediment increase from the proposed salvage logging is within the range of natural variability of the sediment yields for the streams within the project area. Any sediment that would eventually reach stream channels will be flushed through the system within the first or second run-off seasons, dependent on snow pack accumulations and spring runoff events.

For the entire West-side Reservoir Project salvage sales for Alternative D, the additional sediment potentially delivered to stream channels increases by 0.11% from naturally delivered sediment due to the wildfire. The comparisons between estimated naturally delivered sediment resulting from the wildfire and additional sediment delivered from the proposed salvage including construction of helicopter landings with Alternative D are summarized in Table 3-56.

Table 3-56: Alternative D potential delivered sediment with and without salvage treatment.

	Post – Fire Naturally Delivered Sediment (tons)	Alternative D: Potential Additional Delivered Sediment with Salvage (tons)
Beta – Doris Fires	31,922	83
Doe – Blackfoot Fires	101,499	93
Ball Fires	79,401	53
52 Helicopter Landings	0	5
TOTALS	212,822	234

Road Management

With the implementation of Alternative D, there would be 52 miles of road that is currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned.

Alternative D proposes 69 miles of road decommissioning. Road decommissioning is estimated to involve 43 culvert removals in perennial and ephemeral streams for Alternative D. See Table 3-57 for the estimated sediment associated with these culvert removals.

In Alternative D, there are 5 miles of road proposed to be open seasonally, which requires 8 miles that currently exist in this category be converted either into a road closed yearlong with a gate or a berm. Either of these situations allows for more natural re-vegetation of the road surface, which decreases potential for soil erosion from the road surface. Therefore, an 8 mile decrease in the open seasonally road mileage would have a slight positive effect to water quality. There would not be a change to the water quantity situation.

Table 3-57: Estimated number of culvert removals associated with the Alternative D proposed road decommissioning and the related sediment yield from this activity.

Culvert Removals (Depth)		Sediment Yield (Tons)
Shallow	4	18.4
Moderate	8	35.2
Deep	31	387.5
Totals	**43**	**441.1**

In Alternative D, there are 46 fewer miles of road closed yearlong with a gate than the existing road access situation. The majortiy of those miles would be converted to decommissioned roads under Alternative D. The effect of this road management change would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process.

The other category of road management that increases in mileage under Alternative D is the restricted yearlong with a berm class. In Alternative B, there are 82 miles of road proposed to be restricted yearlong with a berm, which is 33 miles more than currently exists. Under Alternative D there are 4 miles of roads currently closed yearlong and re-vegetated that are proposed for log hauling during the salvage operations and are referred to as "temporary road construction". During the logging operation any natural re-vegetation would be removed from the road surface, thus slightly increasing the amount of potential sedimentation from those roads for several years. These roads would be closed yearlong with a berm at completion of salvage operations.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning unless a culvert is identified as having a high risk of failure. If a culvert were identified as high risk one of three actions would occur:

- High-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity;
- The high-risk culvert would be removed if maintenance problems were not created beyond the removal site.
- The majority of the fill over a culvert would be removed and the overlying road surface would be rock-armored to minimize erosion if the pipe should become plugged

If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure. This road management scenario allows the road surface to re-vegetate, which significantly reduces mid-term and long-term sedimentation.

Under Alternative D there are 49 miles fewer motorized trails. The motorized trails are being converted to non-motorized trails. This would reduce the erosion/sedimentation potential from those trails slightly, as compared to when the trails were motorized.

Under Alternative D there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in the project area watersheds. Therefore Alternative D has a long-term positive effect on the sediment load (40.3 tons annual reduction), as compared to the no-action Alternative A. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative D is 441.1 tons.

Alternative E

Sediment from proposed salvage

The modeled potential sediment increase from the Alternative E proposed salvage logging is 234 tons, from the 5338 acres of proposed salvage with 52 landings. The additional delivered sediment to stream channels within the Beta-Doris Fire area with the salvage logging treatments is 0.26% of the potential sediment delivered by wildfire conditions. From the Doe – Blackfoot Fire area the additional sediment delivered to stream channels with salvage logging treatments is 0.09% of the potential sediment delivered by wildfire. Salvage logging on the Ball Fire area will increase the sediment delivered to stream channels by 0.07%. The small amounts of sediment that eventually reach stream channels will be flushed through the system within the first or second run-off seasons.

For the entire West-side Reservoir Project salvage sales for Alternative E, the additional sediment potentially delivered to stream channels increases by 0.11% from naturally delivered sediment due to the wildfire. The comparisons between estimated naturally delivered sediment resulting from the wildfire and additional sediment delivered from the proposed salvage including construction of helicopter landings with Alternative E are summarized in Table 3-58.

Table 3-58: Alternative E potential delivered sediment with and without salvage treatment.

	Post – Fire Naturally Delivered Sediment (tons)	Alternative E: Potential Additional Delivered Sediment with Salvage (tons)
Beta – Doris Fires	31,922	83
Doe – Blackfoot Fires	101,499	93
Ball Fires	79,401	53
52 Helicopter Landings	0	5
TOTALS	212,822	234

Road Management

With the implementation of Alternative E, there would be 38 miles of road currently open yearlong changed to a more restrictive road management category; either open seasonally, closed yearlong with a gate, closed yearlong with a berm, or decommissioned.

Alternative E proposes 49 miles of road decommissioning. Road decommissioning is estimated to involve 42 culvert removals in perennial and ephemeral streams for Alternative E. See Table 3-59 for the estimated sediment associated with these culvert removals.

In Alternative E, there are 33 miles of road proposed to be open seasonally, which is 20 miles more than currently exists. As discussed earlier, roads open seasonally receive less maintenance than roads open yearlong, sometimes resulting in slightly higher road surface erosion. Therefore, a 20 mile increase in the open seasonally road mileage would have a slight negative effect to water quality. There would not be a change to the water quantity situation.

Table 3-59: Estimated number of culvert removals associated with the Alternative E proposed road decommissioning and the related sediment yield from this activity.

Culvert Removals (Depth)		Sediment Yield (Tons)
Shallow	4	18.4
Moderate	11	48.4
Deep	27	337.5
Totals	**42**	**404.3**

In Alternative E, there are 60 fewer miles of road closed yearlong with a gate than the existing road access situation. The majortiy of those miles are being converted to decommissioned roads under Alternative E. The effect of this road management would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction from the road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

The other category of road management that increases in mileage under Alternative E is the restricted yearlong with a berm class. In Alternative E, there are 85 miles of road proposed to be restricted yearlong with a berm, which is 36 miles more than current road access. Under Alternative E there are 4 miles of roads currently closed yearlong and re-vegetated that are proposed for log hauling during the salvage operations and are referred to as “temporary road construction”. During the logging operation any natural re-vegetation would be removed from the road surface, thus slightly increasing the amount of potential sedimentation from those roads for several years. These roads would be closed yearlong with a berm at completion of salvage operations.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning unless a culvert is identified as having a high risk of failure. If a culvert were identified as high risk one of three actions would occur:

- High-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity;
- The high-risk culvert would be removed if maintenance problems were not created beyond the removal site.
- The majority of the fill over a culvert would be removed and the overlying road surface would be rock-armored to minimize erosion if the pipe should become plugged

If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure. This road management category allows the road surface to re-vegetate, which significantly reduces mid-term and long-term sedimentation.

Under Alternative E there are 24 miles fewer motorized trails. The motorized trails are being converted to non-motorized trails. This would reduce the erosion/sedimentation potential from those trails slightly, as compared to when the trails were motorized.

Under Alternative E there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in the project area watersheds in which road-decommissioning work is proposed. Therefore Alternative E has a long-term positive effect on the sediment load (39.7 tons annual reduction), as compared to the no-action Alternative A. The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under Alternative E is 401.0 tons.

Summary of Direct and Indirect Effects

The effects indicators are summarized in Table 3-60.

Table 3-60: Summary of Effects Indicators for All Alternatives

EFFECTS INDICATOR	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Potential Post-fire Delivered Sediment Yield Increase (tons) from Proposed Salvage	0	234	182	234	234
Sediment Yield Increase (tons) from Culvert Removal Associated with Road Decommissioning	0	404.3	424.9	441.1	404.3
Potential Annual Sediment Reduction – Road Decommissioning	0	-39.7 tons/year	-39.8 tons/year	-40.3 tons/year	-39.7 tons/year

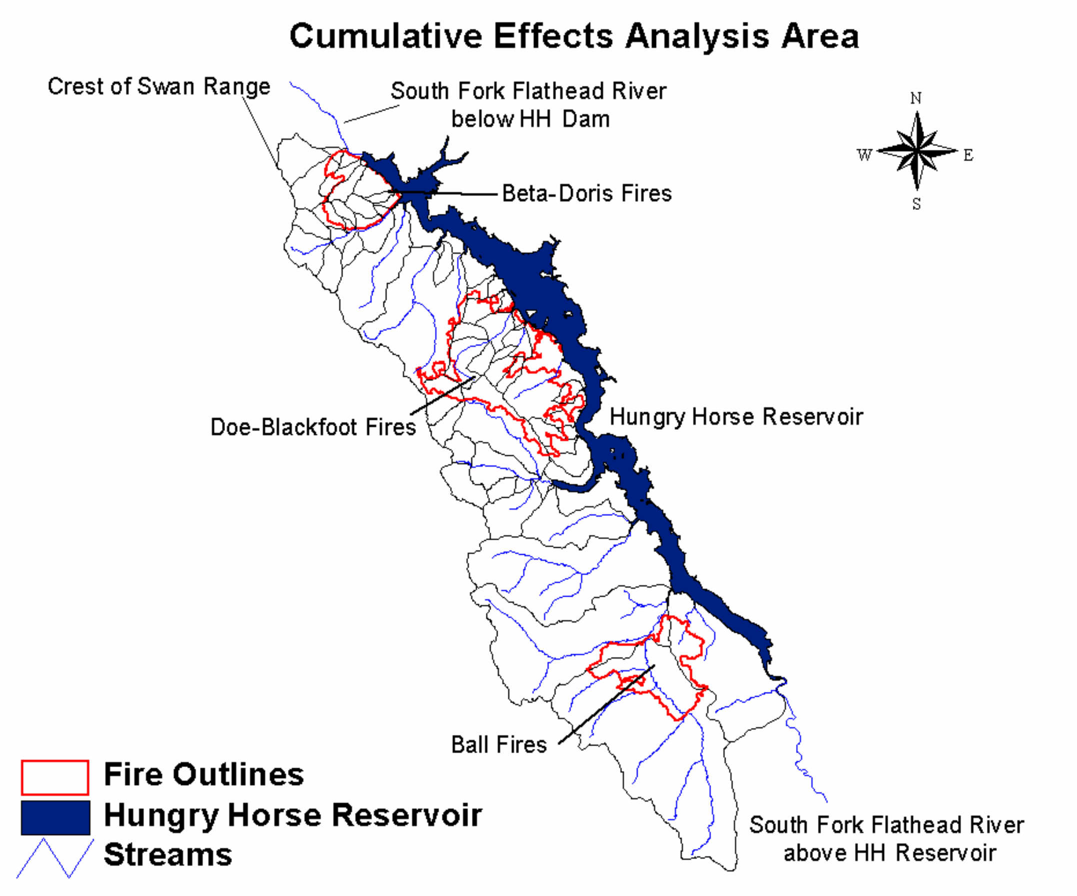
Cumulative Effects

Cumulative effects to water quantity and water quality are described for each alternative in the West-side Reservoir Project. Past actions, current actions and foreseeable actions are all considered within the cumulative effects analysis for all alternatives. Previous sections have described the water quantity and water quality analysis that have been considered during the Draft EIS process.

Analysis Area for Cumulative Effects

The analysis area for the cumulative effects analysis was based on the grouping of watersheds that experienced wildfire in 2003 in combination with the unburned watersheds between the major fire areas (Beta-Doris, Doe-Blackfoot, and Ball). Similarities in geology, geomorphology and precipitation regime also combined all watersheds on the eastern flank of the Swan Range from the headwaters to Hungry Horse Reservoir into the cumulative effects analysis area. The western boundary consists of the crest of the Swan Range as the headwaters of the watersheds included in the cumulative effects analysis area. The eastern boundary of the cumulative effects analysis area begins on the North at the confluence of Aurora/Fawn Creek with the South Fork River below Hungry Horse Dam and extends south along Hungry Horse Reservoir to the confluence of the Upper South Fork River. Hungry Horse Reservoir forms the eastern boundary of the analysis area for cumulative effects due to its function as a sediment and nutrient sink for all watersheds draining the eastern flank of the Swan Range. The volume of water contained by the reservoir will effectively absorb and dilute beyond measurable amounts the incoming water yield increase from the wildfire and the incoming sediment and nutrient yield increases from the wildfire and from the proposed action alternatives. For these reasons the cumulative effects analysis area includes the watersheds within and in between the various fire areas and Hungry Horse Reservoir to the dam. All watersheds included are displayed in Figure 3-17.

Figure 3-17. Cumulative Effects Analysis Area



Past Activities Common to all Alternatives

There are three past management actions that will contribute to the cumulative effects from the West-side Reservoir Fires and subsequent Project:

- Fire suppression – fire line construction and aerial retardant drops to contain spread of fire;
- Burn Area Emergency Rehabilitation (BAER) projects;
- Existing road system.

Fire Suppression Activities

The fire suppression activity on the Beta, Ball, and Blackfoot Complex Fires included both ground and aerial attack of the fire, using hand lines, dozer or excavator (mechanized) lines, fire retardant and water drops from aircraft. The Project File contains a GIS map (Exhibit G-9) of the firelines constructed for all the fires in the West-side Reservior Project Area. The map reflects both hand lines and dozer or excavator lines that were constructed and the existing roads and trails that were used for fire lines. Because several of the firelines are outside of the individual fire boundaries or are shared by two fires, the mileages of firelines are totals for the entire West-side Reservior Project Area and not individual fires.

Approximately 50 miles of handline and dozer or excavator fireline were constructed on the Beta, Ball, and Blackfoot Complex Fires. All firelines were rehabilitated as soon as safe fire conditions made that possible. Rehabilitation included replacing disturbed soil, covering the soil with slash and debris, and construction of waterbars on slopes. There should be no measurable amount of sediment from the constructed firelines. Inspection of the rehabilitated lines took place in the fall of 2003, and monitoring will continue in the summer of 2004 to insure that the firelines are not channeling sediment to the stream network.

Approximately 7.0 miles of existing road network on the west side of Hungry Horse Reservoir were utilized as fireline in portions of the Beta, Ball, and Blackfoot Complex Fires. Use of roads for firelines typically requires some blading of the road surface (especially on roads administratively closed for several years where bush had grown in), and clearing fuels from ditches. Of the entire 7.0 miles of existing road, 1.3 miles were previously decommissioned. There was 10.4 miles of roads used for firelines on the eastside of Hungry Horse Reservior. There was 3.4 miles of existing trail used for fireline that required the removal of fuels, much like a handline construction.

Firelines either crossed a perennial or intermittent stream channel, or entered a Riparian Habitat Conservation Area (RHCA) approximately 28 times in the Beta, Ball, and Blackfoot Complex fires. The construction of the fireline exposed bare soils until fire suppression actions were rehabilitated. Small amounts of additional sediment were potentially introduced into streams at these crossing sites. Only the portion of the road or trail prism directly 30-40 feet upslope of the fireline crossing would be a potential sediment source, because all firelines were water-barred after the suppression activities. The potential sediment from each stream crossing based upon the WEPP-ROAD interface of the soil erosion model would be approximately 14.7 pounds per year for the first 2-3 years, or until revegetation occurs. This is a total of approxiamtely 0.2 tons per year of potential sediment yield from these stream crossings. A handline was constructed parallel to a stream within a Riparian Habitat Conservation Area (RHCA) on one unname tributary to Wounded Buck Creek and some sediment entered the creek during the construction of this line, prior to rehabilitation, but the amount would have been very small, estimated to be in the low hundreds of pounds. The potential sediment produced from fireline construction activities would be impossible to detect versus natural background levels for each individual stream.

Based upon the best available information there was no fuel (gasoline or oil) spilled into any riparain area or stream channel during the fire suppression or post-fire rehabilitation activities.

The fire suppression activities for the West-side Reservoir Fires included aerial suppression using fire retardant and water drops from aircraft. Approximately 39,460 gallons of Phos-Chek D75-R retardant was deployed with air tankers on the West-side Reservoir watersheds between August 21 and September 7, 2003. Retardant use protocols restrict application within 300 feet of streams. Norris and Webb (1989) reported that when retardant is applied outside the riparian zone there are minimal long-term effects on water quality. Little and Calfee (2000) reported that there are two possible effects to water quality that can affect aquatic organisms associated with some types of fire retardant:

- When some types of fire retardant are exposed to sunlight (UV rays), the sodium ferrocyanide used as a corrosion inhibitor can undergo photo activation. The toxicity of those retardant formulations increases significantly. The Phos-Chek D75-R retardant formula does not contain any sodium ferrocyanide. Little and Calfee (2000) reported, "No free cyanide was detected for either Phos-Chek D75-R or Phos-Chek D75-F under any lighting conditions." Therefore, the water quality for the West-side Reservoir watersheds are not affected by any increased ferrocyanide due to the retardant drops.
- Fire retardant releases ammonia with the most probable entry into stream water by direct application or in association with overland flow. Little and Calfee (2002) reported that Phos-Chek D75-R contains un-ionized ammonia within a range of concentrations that ranged from 0.11 to 0.14 mg/L. The acutely toxic range of concentrations for rainbow trout is 0.08 to 1.1 mg/L. Phos-Chek D75-R contains 11.3% by weight the active salts ammonia sulfate and ammonia phosphate. Each gallon of mixed retardant contains the equivalent of 1.12 pounds of the Phos-Chek formula. For fires in heavy slash/forest, retardant use is at least 6 gallons per 100 square feet (Adams and Simmons, 1999).

As described earlier in the post-fire nutrient discussion, ammonia levels in burned watersheds increase sharply after a fire and then return to post-fire levels rather quickly. This is due to the absorption of moderate to low levels of any available ammonia by the volcanic ash topsoil found in this area. The retardant drops would have additionally increased the post-fire background ammonia levels of the surface soils where the drops occurred in the project area watersheds. However, as Norris and Webb (1989) discussed there should be no long-term effect to the water quality from the application of fire retardant in the upland portion of the West-side Reservoir Project Area watersheds.

Burned Area Emergency Response (BAER) Projects

In the fall of 2003, the BAER team implemented the emergency rehabilitation treatments for the Beta, Ball and Blackfoot Complex Fires.

There was emergency road drainage work completed to accommadate the increased stream flows following the wildfires that included:

- Road #975 – installing one 36" flared culvert inlet and armor;
- Road # 547 - installing two 36" flared culvert inlets and armor the inlets, install new 24" culvert, install 18" flared culvert inlet, install new 24" emergency overlow culvert and armor fillslope, construct armored overflow dip;
- Road #2816 – construct armored overflow dip, and install 48" flared culvert inlet and armor, remove 48" culvert;

- Road # 9838 – install 36" flared culvert inlet and armor, and install 48" flared culvert inlet and armor;
- Road #895 – clean inlet of 48" culvert, armor outlet and ditch line associated with several culverts, and install new 24" culvert;
- Road #1605 – clean culvert inlets of three 36" culverts.

Throughout the fire there was other miscellaneous road maintenance including the cleaning of stream and ditch relief culvert inlets. All work was completed in the fall of 2003. Work to be completed the summer of 2004 includes the removal of two 18" culverts on Road #1601.

To reduce the potential for post-fire soil erosion, areas of high soil burn severity were aerial seeded with grass seed and/or barley in portions of all fire areas during the fall of 2003. In the Ball Fire several thousand feet of straw wattles were installed to reduce sediment transport into Sullivan Creek. In the lower portion of Goldie Creek there was straw mulch aerially applied to an area of steep slopes that had severely burned. In this area shrubs were planted to help reduce the erosion potential. Aerial grass seeding was completed on portion of the Blackfoot Fire (lower Goldie Creek) and the Ball Fire (lower Sullivan Creek) in October 2003.

During field season 2004, two other projects are being completed:

- Hazard trees along approximately 30 miles of trails in the fire areas are being cut down for public safety;
- Surveys for and the treatment of noxious weed infestations are occurring in the fire areas.

Existing Road System

As previously discussed, timber harvest occurred for several decades within the West-side Reservoir Project area. The timber harvest areas were revegetated prior to the wildfires of 2003, and therefore were not contributing to the sediment budget of the analysis watersheds. However, long-term effects to the watershed from these past activities exist from the road system that was built to facilate the transportation of the logs. As described eariler the annual sediment yeild from the existing road system in the anaylsis area is approximately 66.1 tons.

Foreseeable Actions Common to all Alternatives

There are four reasonably foreseeable actions identified that could potentially have a measurable effect to water quantity or quality:

- The Post-fire Road Best Management Practices (BMPs) Project - culvert replacements;
- The Post-fire Road BMPs Project - road drainage improvements;
- Road decommissioning associated with the Spotted Beetle Resource Project EIS;
- Routine road maintenance.

These are discussed in the following section. The foreseeable actions with no effects to the water quality or quantity include:

- The noxious weed treatments;
- Recreation activities;
- Special products activities (e.g. mushroom picking);
- Fire woodcutting.
- Pheromone treatments

The interpretation is based upon applicants following the label instructions for proper use of any herbicide, and that woodcutters follow the limitations associated with the wood gathering permits.

Culvert Replacements/ Road BMP Improvements

For the proposed West-side Reservoir project, the primary direct effect to the water resource is the potential increase in sedimentation directly associated with either the culvert replacement process, or the Best Management Practices (BMPs) road drainage improvements. Culvert replacements and BMP improvements on the West-side Reservoir Project are being addressed separately from this EIS in another NEPA document, with activities to begin in the summer of 2004 and to be completed in 2005.

The following is an estimate of the total amount of erosion and associated sedimentation that occurs during the process of replacing or up-sizing a culvert. The erosion material comes from two different sources:

- The area beneath a culvert in the streambed that is exposed to water-flow during the removal process;
- The side-slopes of the road prism that are excavated during the replacement process.

Some erosion occurs in the streambed during the replacement process even with de-watering, due to the seepage of groundwater around or under the stream-crossing segment, unless the stream is totally dry. Road side-slopes become bare ground following excavation even with erosion control and sediment reduction measures installed and it is probable that some erosion occurs before the bare ground surfaces become re-vegetated. Because both of these erosion areas are within or directly next to a stream, any fine eroded soil material may immediately become suspended sediment.

The short-term increase in sediment varies with the soil materials around the culvert and the hillslope at the culvert site. The steeper the site, the more soil is exposed to erosion. The less the coarse fragment content, and the finer the soil texture, the more potential for soil erosion. This is especially true with saturated soils that occur in the bottom of perennial streams. Based upon observations by the FNF soil scientist and hydrologist, estimates for the amount of soil erosion from the stream bottom and road side-slopes were developed. These estimated erosion rates were then multiplied by the exposed surface area for various widths and depths of culvert replacements to develop the estimated erosion/sediment potential for various culvert replacement scenarios. The estimates are displayed in Table 3-61

Table 3-61: Estimated total erosion/sedimentation that occurs during a culvert replacement process, for both shallow and deep sites, during both a normal replacement scenario and a worst-case scenario.

Culvert Width - Erosion Scenario	Estimated Erosion/Sedimentation Flatter/Shallow Site	Estimated Erosion/Sedimentation Steeper/Deep Site
2 Foot – Dry Normal Resize	0.3 tons/culvert	1.2 tons/culvert
2 Foot – Wet Normal Resize	0.6 tons/culvert	1.9 tons/culvert
2 Foot – Wet Worst Case Resize	0.8 tons/culvert	2.7 tons/culvert
3 Foot – Dry Normal Resize	0.4 tons/culvert	1.3 tons/culvert
3 Foot – Wet Normal Resize	0.7 tons/culvert	2.4 tons/culvert
3 Foot – Wet Worst Case Resize	1.1 tons/culvert	3.5 tons/culvert
4 Foot – Dry Normal Resize	0.4 tons/culvert	1.4 tons/culvert
4 Foot – Wet Normal Resize	0.9 tons/culvert	2.9 tons/culvert
4 Foot – Wet Worst Case Resize	1.4 tons/culvert	4.4 tons/culvert
5 Foot – Dry Normal Resize	0.5 tons/culvert	1.0 tons/culvert
5 Foot – Wet Normal Resize	1.1 tons/culvert	3.4 tons/culvert
5 Foot – Wet Worst Case Resize	1.7 tons/culvert	5.3 tons/culvert

Culverts in the Westside Project Area will be examined for signs of erosion or deposition upstream or downstream of the culvert, which indicates an undersized culvert. The rust lines will be measured for each culvert. Rust lines represent an approximation of the bankfull or the 1.5 to 2 year return interval flow for the stream. For the purpose of initial estimate for culverts that need to be upsized to meet INFISH requirements, a rust line height greater than 33% of the culvert diameter was assumed to need upsizing. Modeling of estimated water flow for various return interval events (e.g. 50-year flow, 100-year flow) is being done concurrently with this assessment. Each culvert would be re-examined in the field and flow estimations reviewed before a culvert would be replaced in order to insure the need for replacement, and minimize the amount of sediment produced from the replacement process.

The field surveys for culvert replacements are not completed at this time and will be completed between the draft and final EIS. The district hydrologist and district road manager estimated the BMP improvements and culvert replacements for roads in the three fire areas. Based upon best professional judgment the culvert replacements in the three fires are:

- Ball Fire 5 culverts approximately 3 feet in diameter:
- Beta Fire 6 culverts approximately 4 foot in diameter and 2 culverts >5 feet in diameter,
- Blackfoot Fire 13 culverts approximately 3 foot in diameter and 4 culverts approximately 4 feet in diameter.

Each potential culvert replacement site was given a potential sediment yield based upon the estimated culvert size and site type (deep/shallow and wet/dry replacement) from Table 3-22 and the estimated erosion/sedimentation associated with all culvert replacements is 87.8 tons.

The estimated replacement of these 30 culverts would result in the potential release of approximately 87.8 tons of sediment into the tributary streams of West-side Reservoir Project during the next 3 to 4 years. The vast majority (85%) of sediment results from the direct replacement process and the remainder (15%) are associated with the disturbed road prism side-slopes until complete re-vegetation.

The primary BMPs that are proposed on the roads in the three fire areas are directly associated with improving water drainage from the surface of roads, and improving the filtering of sediment coming from road surface and ditch drainage. These BMP projects primarily include installation of new cross-drain culverts, drive-thru-dips, road surface water deflectors (flappers), and sediment retention structures (silt fencing, straw wattles, slash filter windrows). It is anticipated that no measurable amounts of sedimentation are associated with any slash filter windrow, or silt fence installation. It is anticipated that no measurable amounts of sedimentation deliverable to a stream are associated with the installation of drive-thru-dips, except for the drive-thru-dips that are constructed very near to a stream channel.

Based upon the a map review of the roads with BMPs improvements proposed, there are approximately 40 total stream crossings in the West-side Reservoir Project that could have sedimentation potential from the construction of the drive-thru-dips. From the total, approximately 15 stream crossings are on "flatter/shallow" crossing sites and have less potential for soil erosion due to flatter road grade but have less filtration buffer length. The "steeper/deep" crossing sites have more potential for soil erosion due to the steeper road grade, but have longer filter distances from the road surface to the stream than the "flatter/shallow" stream crossing. The remaining approximate 25 stream crossings are on steeper/deep situation. Based upon WEPP-ROAD soil erosion modeling, the installation of a drive-thru-dip at approximately 30 feet from each side of the stream crossing would yield approximately 11.1 pounds per year of sediment for a "flatter/shallow" site, and 14.7 pounds per year for a "steeper/deeper" site. The construction of the drive-thru-dips would potentially increase the sediment budget to the streams in the Westside Project Area by 0.27 tons. The sediment would go into the streams during the first year following construction. As with the culvert replacements, exact numbers of required drive-thru-dips will be developed during the field surveys this summer and between draft and final EIS. Table 3-62 summarizes the potential sediment potentially produced from installation of BMPs throughout the West-side Reservoir Project.

Table 3-62: Best Management Practices for Roads of the West-side Reservoir Project

BMP Activity	Estimated Sediment Produced
Culvert Replacements	87.8 tons
Drive-through Dips	0.27 tons
Total	**88.1 tons**

Road Decommissioning

The Spotted Beetle Resource Project decision notice was signed in March of 2002, and required 18.0 miles of roads decommissioning in Taylor Creek and Clark Creek basins. Taylor Creek and Clark Creek are within the analysis watersheds for the West Side Reservoir

Post-fire Project. Within the cumulative effects analysis area, decommissioning roads: #1115A, #9845, #11453, #9734, #2831, #2831C, #10130, and #10339 would occur during the summer season of years 2005, 2006, and 2007. Table 3-63 reports the estimated sediment yield associated with the culvert removals during that road decommissioning.

Table 3-63: The estimated number of culvert removals and associated sediment yield from road decommissioning in West Side Reservoir Post-fire Project assessment watersheds, under the Spotted Beetle EIS decision.

Culvert Removals (Depth)	Spotted Beetle EIS – Under Decision	Sediment Yield (Tons)
Shallow	0	0
Moderate	5	22.0
Deep	5	62.5
totals	**10**	**84.5**

This foreseeable action of road decommissioning would have a short-term negative effect to the water quality (sediment increase) within the basins; however, in the long-term there would be an overall positive effect to the water quantity (water yield decrease) and quality (sediment decrease) within each basin due to road decommissioning.

Road Maintenance

There is a foreseeable action of routine road maintenance (road grading) that would be done as needed during the salvage sale. At the conclusion of the salvage sales no other grading would be done due to budget constraints. The existing road sediment yield (66.1 tons) modeled previously accounts for any effect of the road grading on existing roads.

Alternative A – No Action

Past Actions: The past actions described earlier in this section include: past road construction, past road decommissioning, the fire suppression activities for the West-side Reservoir Project, and the Burned Area Emergency Rehabilitation.

Foreseeable Actions: The foreseeable actions anticipated for Alternative A include: the post-fire BMP project including both culvert replacements and road drainage improvements; road decommissioning associated with the Spotted Beetle Resource Project EIS; and routine road maintenance. Refer to Table 3-64 for a listing of the existing post-fire sediment yield from the existing situation and foreseeable actions.

The effects of the wildfire on nutrients, and sediment and water yield increases have been described in previous sections. A decrease to long-term sediment and water yield would be foregone if the road decommissioning proposed in Alternatives B through E were not implemented.

Table 3-64: The summary of the sediment producing activities for the West-side Reservoir Project including: background, foreseeable actions, and Alternative A: no action.

Sediment Producing Activity	Tons of Sediment
Post-fire Potential Sediment from all burned areas in analysis watersheds of the West-side Reservoir Project	212,822
Annual Existing Road Potential Sediment on West-side Reservoir Project	66
Total Short-term Potential Sediment Increase from Spotted Beetle Resource Project EIS Road Decommissioning	85
Total Short-term Potential Sediment due to implementation of Post-fire BMPs: both road decommissioning and culvert replacements	88

Alternative B

Past Actions: The past actions are the same as described for Alternative A.

Foreseeable Actions: The foreseeable actions that may affect the water resources were described earlier in this section and include:

- proposed post-fire road Best Management Practices (BMPs) project - drainage improvements;
- proposed post-fire BMPs project - culvert replacements; and
- road decommissioning associated with the Spotted Beetle Resource Project EIS;
- routine road maintenance.

Proposed Actions: The Alternative B proposed salvage harvesting, road/landing construction, and road decommissioning would not have any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under Alternative B would increase the sediment loading in the analysis watersheds by 234 tons for the West-side Reservoir Project. Road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (39.7 tons/year), after the initial short-term sediment increase (404.3 tons) during the culvert removal/stream readjustment time. The risk of culvert failure would also decrease with the proposed road decommissioning

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative B, the level of nutrients (i.e. nitrogen and phosphorus) should increase. This nutrient increase is very small in comparison to the nutrient increase caused by the wildfire. In combination, the amount of potential nutrient increase from the Alternative B timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation after stream flow from the analysis watersheds reaches the waters of Hungry Horse Reservoir. Refer to Table 3-65 for a listing of the existing post-fire sediment yield, the additional sediment yield from the Alternative B proposed actions and other foreseeable actions.

Table 3-65: The summary of the sediment producing activities for the West-side Reservoir Project including: background, foreseeable actions, and Alternative B proposed actions.

Sediment Producing Activity	Tons of Sediment
Post-fire Potential Sediment from all burned areas in analysis watersheds of the West-side Reservoir Project	212,822
Annual Existing Road Potential Sediment on West-side Reservoir Project	66
Total Short-term Potential Sediment Increase from Spotted Beetle Resource Project EIS Road Decommissioning	85
Total Short-term Potential Sediment due to implementation of Post-fire BMPs : both road decommissioning and culvert replacements	88
Total Short-term Potential Sediment from Culvert Replacements	404
Potential Sediment from Alt-B Proposed Salvage[1]	234
Annual Long-term Potential **Decrease** Sediment from Alt-B Road Decommissioning[2]	-40

[1] Note that sediment yield from salvage harvesting decreases rapidly as vegetation recovers.
[2] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that are outside the measured natural range of variation for watersheds on the West-side Reservoir Project. Given normal climatic events in the next two years, the sediment yield would also be within the natural range of variation. Given a significant storm event, the sediment yield for the West-side Reservoir watersheds could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative C

Past Actions: The past actions are the same as described for Alternative A.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative B.

Proposed Actions: The Alternative C proposed salvage harvest, road/landing construction and road decommissioning would not result in any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under Alternative C would increase the sediment loading in the analysis watersheds, by a total of approximately 182 tons for the West-side Reservoir Project. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (39.8 tons/year), after the initial short-term sediment increase (424.9 tons) during the culvert removal/stream readjustment time

Refer to Table 3-66 for a listing of the existing post-fire sediment yield, the additional sediment yield from the Alternative C proposed actions and other foreseeable actions.

Table 3-66: The summary of the sediment producing activities for the West-side Reservoir Project including: background, foreseeable actions, and Alternative C proposed actions.

Sediment Producing Activity	Tons of Sediment
Post-fire Potential Sediment from Burned Portion of analysis watersheds of the West-side Reservoir Project	212,822
Annual Road Maintenance Potential Sediment on West-side Reservoir Project	66
Total Short-term Potential Sediment Increase from Spotted Beetle Resource Project EIS Road Decommissioning	85
Total Short-term Potential Sediment due to implementation of Post-fire BMPs : both road decommissioning and culvert replacements	88
Total Short-term Potential Sediment from Culvert Replacements	425
Potential Sediment from Alt-C Proposed Salvage[1]	182
Annual Long-term Potential **Decrease** Sediment from Alt-C Road Decommissioning[2]	-40

[1] Note that sediment yield from salvage harvesting decreases rapidly as vegetation recovers.
[2] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative C, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the Alternative C timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation after stream flow from the analysis watersheds reaches the waters of Hungry Horse Reservoir.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for the West-side Reservoir analysis area. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation. Given a significant storm/soil erosion event, the sediment yield for could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative D

Past Actions: The past actions are the same as described for Alternative A.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative B.

Proposed Actions: The Alternative D proposed salvage harvest, road/landing construction, and road decommissioning would not result in any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under Alternative D would increase the sediment loading in the analysis watersheds, by a total of approximately 234 tons for the West-side Reservoir Project. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (40.3 tons/year), after the initial short-term sediment increase (441.1 tons) during the culvert removal/stream readjustment time. The risk of culvert failure would also decrease with the proposed road decommissioning.

Refer to Table 3-67 for a listing of the existing post-fire sediment yield, the additional sediment yield from the Alternative D proposed actions and other foreseeable actions.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in Alternative D, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the Alternative D timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation after stream flow from the analysis watersheds reaches the waters of Hungry Horse Reservoir.

Table 3-67. The summary of the sediment producing activities for the West-side Reservoir Project including: background, foreseeable actions, and Alternative D proposed actions.

Sediment Producing Activity	Tons of Sediment
Year-1 Post-fire Potential Sediment from all burned areas in analysis watersheds of the West-side Reservoir Project	212,822
Annual Road Maintenance Potential Sediment on West-side Reservoir Project	66
Total Short-term Potential Sediment Increase from Spotted Beetle Resource Project EIS Road Decommissioning	85
Total Short-term Potential Sediment due to implementation of Post-fire BMPs : both road decommissioning and culvert replacements	88
Total Short-term Potential Sediment from Culvert Replacements	441
Potential Sediment from Alt-D Proposed Salvage[1]	234
Annual Long-term Potential Decrease Sediment from Alt-D Road Decommissioning[2]	-40

[1] Note that sediment yield from salvage harvesting decreases rapidly as vegetation recovers.
[2] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for West-side Reservoir Project. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for the West-side Reservoir Project. Given a significant storm event, the sediment yield for the West-side Reservoir Project could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Alternative E

Past Actions: The past actions are the same as described for Alternative A.

Foreseeable Actions: The foreseeable actions are the same as described for Alternative B.

Proposed Actions: The proposed action under Alternative E for the salvage harvest, road and landing construction is the same as Alternative B.

The effects to water yield, sedimentation yield, and nutrient yield are virtually identical to those for Alternative B. Refer to Table 3-68 for a listing of the existing post-fire sediment yield, the additional sediment yield from the Alternative E proposed actions and other foreseeable actions.

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for West-side Reservoir Project. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation. Given a significant storm event, the sediment yield could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

Table 3-68: The summary of the sediment producing activities for the West-side Reservoir Project including: background, foreseeable actions, and Alternative E proposed actions.

Sediment Producing Activity	Tons of Sediment
Post-fire Potential Sediment from all burned areas in analysis watersheds of the West-side Reservoir Project	212,822
Annual Road Maintenance Potential Sediment on West-side Reservoir Project	66
Total Short-term Potential Sediment Increase from Spotted Beetle Resource Project EIS Road Decommissioning	85
Total Short-term Potential Sediment due to implementation of Post-fire BMPs : both road decommissioning and culvert replacements	88
Total Short-term Potential Sediment from Culvert Replacements	404
Potential Sediment from Alt-B Proposed Salvage[1]	234
Annual Long-term Potential **Decrease** Sediment from Alt-B Road Decommissioning[2]	-40

[1] Note that sediment yield from salvage harvesting decreases rapidly as vegetation recovers.
[2] The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Cumulative Effects Conclusion

The water quantity increase caused by the wildfire has the potential to destabilize stream channels and increase bank erosion. The water quantity increase due to proposed salvage operations after the wildfire will not be measurable when compared to that caused by the wildfire. Stream destabilization and bank erosion are now dependent on the variations posed by the regional climatic regime. Extreme storm events have the potential to change stream stability and effect bank erosion. The salvage operations themselves will not lead to an increase in water yield but will facilitate the major conduits of water (roads) to be managed in a manner that decreases the potential for increased water yield to reach stream channels. In addition, the level of post-fire water yield increase will diminish by the time the salvage harvest and road decommissioning are actually implemented.

Changes in water quality are due to eroded material that actually reaches the stream channel to become sediment. The potential deliverable sediment caused by salvage operations in the proposed action alternatives is only 0.3 % of the potential deliverable sediment caused by the wildfire. Management of the sediment conduits to stream channels (roads) is key to decreasing the cumulative effects of sediment yield increases caused by the wildfire. By implementing road BMPs and road decommissioning, sediment yield increases that flow directly into stream channels from the wildfire will be reduced.

REGULATORY FRAMEWORK AND CONSISTENCY

All proposed action alternatives meet the Clean Water Act, Montana State Water Quality Standards, and Forest Plan Water Standards including INFISH RMOs. See Appendix D for a detailed discussion of water regulations that pertain to this project.

Clean Water Act

Section 313 of the Clean Water Act requires that Federal agencies comply with all substantive and procedural requirements related to water quality. Under Section 303 of the Clean Water Act, States have the primary responsibility to develop and implement water quality programs, which include developing water quality standards and Best Management Practices (BMPs). State water quality standards are based on the water quality necessary to protect beneficial uses.

Environmental Protection Agency policy requires each state to implement a Non-degradation Policy. Under this policy, water quality must be maintained to fully support existing beneficial uses. Existing water quality that is higher than the established standards must be maintained at the existing level unless the board of health and environmental sciences determines that a change in water quality is justifiable due to social and/or economic reasons (CFR Vol. 48, No. 217, 131.12, Nov, 8, 1983; Montana Water Quality Act, Section 75-5.)

Montana State Water Quality Law

As listed in ARM 17.30.608 (1) the State of Montana has classified the waters in the Flathead Basin as B-1. Waters classified as B-1 are suitable for drinking, culinary, and food processing purposes after conventional treatment. Water quality must also be suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Additional criteria specific to sediment are found within Section 17.30.623(2) (f) of Montana Water Quality Standards where it is stated that "No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife". Naturally occurring as defined by MCA 17.30.602 (17), includes conditions or materials present during runoff from developed land where all reasonable land, soil, and water conservation practices

(BMPs) have been applied. Reasonable practices include methods, measures or practices that protect present and reasonably anticipated beneficial uses.

The state water quality law relates to the Clean Water Act and the maintenance of beneficial water uses through the use of BMPs. The BMPs are designed to prevent soil erosion and protect water quality, as well as help prevent soil damage. In a Memorandum of Understanding (MOU) with the State of Montana, the Forest Service has agreed to follow Best Management Practices (BMPs) during timber harvest and road construction activities. The West-side Reservoir Project will utilize all applicable BMPs during project design and implementation as described in Best Management Practices for Forestry in Montana – 1997. Also Forest Service - Soil and Water Conservation Practices (FSH 2509.22) will be combined with Montana State BMPs into project design and implementation to ensure that soil and water resources are protected.

Table 3-69. Summarization of landforms with expected nutrient yields in the West-side Reservoir Project

Landform Class	Total Landform acres in analysis group	Total Riparian + Wetland Acres	Most Common Stream Type	Burned Riparian + Wetland Acres	Expected Nitrogen Yield after Fire	Expected Phosphorus Yield after fire
BETA – DORIS FIRES						
Breaklands	135.7	11.9	A	2.1	Moderate	High
Steep alpine glacial land	11862.6	1965.7	A1/Aa+1 or A2/Aa+2	565.1	Moderate	High
Gentle to moderately sloped glacial land	1517.75	421.9	A or B	119.0	Low	Moderate
Mountain slopes and ridges	2751.1	276.0	A	91.7	Moderate	Low
DOE – BLACKFOOT FIRES						
Breaklands	2710.3	215.1	A	92.9	Moderate	High
Steep alpine glacial land	36628.5	5052.2	A1/Aa+1 or A2/Aa+2	1614.2	Moderate	High
Gentle to moderately sloped glacial land	11641.1	3713.4	A or B	742.9	Low	Moderate
Mountain slopes and ridges	6469.7	517.4	A	149.1	Moderate	Low
Mass-wasting slopes	109.0	21.3	A	0.0	Moderate	Moderate - High
BALL FIRES						
Valley bottoms	223.5	200.3	C / E	0.0	Moderate	High
Breaklands	10655.2	670.5	A	212.8	Moderate	High
Steep alpine glacial land	31749.3	3600.4	A1/Aa+1 or A2/Aa+2	336.7	Moderate	High
Gentle to moderately sloped glacial land	12396.6	3827.2	A or B	587.5	Low	Moderate
Mountain slopes and ridges	6464.1	267.5	A	142.8	Moderate	Low

The DEQ's 1996, 2002, and 2004 303(d)/305(b) Reports - *Waterbodies in need of Total Maximum Daily Load (TMDL) Development*, describe Sullivan Creek (Ball Fire) as partially supporting the beneficial uses of aquatic life support and cold water fishery. The probable causes of this impairment on all 303(d) lists are linked to sediment, with probable sources linked primarily to road building associated with silviculture practices.

Montana Streamside Management Zone (SMZ) Law

By definition in ARM 36.11.312 (3), the majority of the streams in Flathead National Forest meet the criteria for a class 1 stream. Some first order ephemeral streams meet the criteria of a class 2 or 3 stream based upon site-specific criteria. All alternatives will meet the minimum SMZ buffer zone requirements.

Forest Plan Standards

The Flathead Forest Plan contains Forest-wide Management Direction that:

- Develop watershed activity schedules for key watersheds;
- Maintain an inventory of non-wilderness areas needing soil and water restoration;
- Complete restoration projects as funds permit; and
- Apply Best Management Practices (BMP's) during Forest Plan implementation to ensure that Forest water quality goals are met.

The Flathead Forest Plan, under Management Area Specific water and soils direction requires that the forest:

- Maintain long-term water quality to meet or exceed State water quality standards;
- Monitor surface-disturbing activities to ensure standards are met;
- Refer to Forest-wide standards under Water and Soils for Best Management Practices, Landtype Guidelines, and standards applicable to projects or activities within specific Management Areas;
- Analyze and evaluate all project proposals to determine the potential water quantity and quality impacts; and
- Develop mitigation measures to minimize adverse impacts.

INFISH and Wetlands Standards

The INFISH (1995) Standards are discussed in detail in the fishery assessment. All timber salvage units were designed to meet the RHCA requirements under INFISH to protect the stream channel and maintain water quality and aquatic habitat. Wetlands are protected under Executive Order 11990. This act directs federal agencies to "minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands..." There are no activities proposed in any of the alternatives of the West-side Reservoir Project that directly affect any lodic or lentic wetlands in the South Fork of the Flathead River in the project area. All alternatives meet Executive Order 11990.