Appendix C – Government Camp Trails Hydrologic and Aquatic Resources Report

GEOLOGY

The underlying geology within and adjacent to the Study Area is described as a large pyroclastic-flow (volcanic-flow) and debris flow deposits in the report entitled, "Preliminary Geologic Map of the Mount Hood 30-Minute by 60-Minute Quadrangle, Northern Cascade Range, Oregon" (U.S. Geological Survey, 1995). These highly permeable pyroclastic and debris flow deposits covered older volcanic deposits to create the smooth fan that is currently discernable between Zigzag Canyon and White River Canyon. The thickness of this debris fan is largely undocumented, however a test well located just south of Timberline Lodge revealed a measured thickness of 120 feet (USFS, 1992). The dominant materials found within this layer include poorly sorted pebbles, cobbles, and boulders in a reddish-gray sandy matrix (U.S. Geological Survey, 1995). It is likely that the young age and high permeability of these deposits are the dominant factors responsible for the limited stream development above Timberline Lodge and the large amount of shallow groundwater flow. Finally, it is thought that the older volcanic deposits found under the permeable pyroclastic and debris flow materials have low permeability and act to concentrate groundwater flow and create groundwater springs at specific elevations where bedrock is exposed (DeRoo, Pers. Comm., July, 2004).

WATER RESOURCES

Management Direction

For ease of analysis a hydrologic planning area was identified for this project. The hydrologic analysis area (HAA) extends from the uppermost extent of any stream where it is intersected by project activities to the bottom of the microwatershed associated project activities. For this project the hydrologic analysis area is 5481 acres.

There are 4 land allocations in the HAA that address water resources. These allocations are detailed in Table 1

Table 1 – Land Allocations related toWatershed Resources

Allocation	Acres	Management Direction
Special Emphasis	765	Maintain or improve watershed, riparian, and aquatic habitat conditions and water quality for municipal uses

Watershed		and/or long term fish production.
Wild and Scenic River	70	Protect and enhance the resource values for which a river was designated into the Wild and Scenic Rivers System
Riparian Reserve	1758	Riparian resources receive primary emphasis and special standard and guidelines apply
Key Site Riparian	226	Maintain or enhance habitat and hydrologic conditions of selected riparian areas, notable for their exceptional diversity, high natural quality and key role in providing for the continued production of riparian dependent resource values.

In addition to the land allocations listed above the Salmon River Fifth Field Watershed is a Tier 1 Key Watershed under the Northwest Forest Plan. There are 975 acres of the HAA in the Key Watershed. The objective of the Key Watershed is to contribute directly to conservation of at-risk anadromous salmonids and resident fish species. The emphasis within Key Watersheds is to reduce existing system and non-system road mileage and receive priority for restoration.

The hydrologic planning area contains 488 acres of the 582 acre Government Camp Drinking Water Protection Area (DWPA). Although the boundary of the Government Camp DWPA has been identified, a Drinking Water Protection Plan has not been developed, and therefore, no management guidelines or protection standards have been established (USDA, 2005).

Climate

The planning area receives approximately 68-114 inches of precipitation annually in the form of rain and snow based on data from PRISM model developed by the Oregon Climate Service . There are two SNOTEL (Snow Telemetry) sites in or adjacent to the project area. The Mt. Hood Test Site is at the lower end of the Timberline Ski area at 5400 feet elevation. The Mud Ridge Site is about 1 mile south of Trillium lake at 3800 feet elevation.

Data from the Mt Hood Test Site site from 1981 through 2004 is summarized in Table 2.

Table 2 – Mt Hood Test Site Climate Summary

	Total Precipitation (inches)	Snowpack measured as inches of Snow Water Equivalent	% of Total Precipitation contained in the Snowpack
Average	106.6	67.1	63
Minimum	68.4	37.9	39
Maximum	152.6	102.4	81

Data from the Mud Ridge Site from 1979 through 2004 is summarized in Table 3.

	Total Precipitation (inches)	Snowpack measured as inches of Snow Water Equivalent	% of Total Precipitation contained in the Snowpack
Average	66.44	28.08	42
Minimum	45.20	6.80	10
Maximum	95.10	45.10	66

Table 3 –Mud Creek Climate Summary

Surface Water Resources

The hydrologic project incorporates two Fifth Field Watersheds (Zigzag and Salmon River) and five Sixth Field Watersheds (Still Creek, Camp Creek, Little Zigzag Canyon, Mud Creek, and West and East Fork Salmon River).

There are 19.0 miles of perennial streams of which 10.4 are classified as fish bearing with resident rainbow and cutthroat trout. Major streams in the project area include Still Creek (4.9 miles), Camp Creek (1.7 miles), and Trillium Lake Tributaries (0.9 miles).

Geomorphology

The headwaters of Still creek emerge out of a set of perennial and ephemeral wetland seeps originating at about the 5000' elevation on the south side of Mt Hood. Fed by snowmelt surface runoff and groundwater flow emanating from the Palmer Snowfield, these numerous wetland seeps join together at the 4800' elevation level and form the mainstem channel of Still Creek (USDA, 2005)

Thick pyroclastic flow and debris flow deposits from approximately 1,500 years ago comprise the surface material in the project area. These permeable deposits filled in over the older topographic surface (including stream channels) and created the present smooth fan on the southwest side of Mt. Hood (U.S. Geological Survey, 1995). The age and permeability of this material explains the limited stream development above Timberline Lodge; the buried topography (including stream channels) probably helps to concentrate groundwater flow in certain areas and partially explains why springs are located where they (DeRoo, Pers. Comm., July, 2004).

The topography of the land around these seeps and wetlands is very steep (30 to 50 percent slope), and because of the steep slopes, these tributary streams all are moderately to highly incised and have distinct stream morphology with limited floodplain development. The perennial reach of the mainstem of Still Creek in the vicinity of the project area is classified as a Rosgen A4a+ channel type. The A4 stream types typically have a high sediment supply which is combined with high energy streamflow to produce very high bedload sediment transport rates. The A4 stream types are generally unstable, with very steep rejuventated banks that contribute large quantities of sediment. A4a+ stream types are usually located in slump/earthflow landforms and are often associated with debris avalanches and debris torrent erosional processes. (Rosgen 1996).

Similar to Still Creek Camp Creek is in the area affected by pyroclastic flow and debris flow deposits from approximately 1,500 years ago. Camp Creek and it's associated tributaries originate from a series of seeps and springs in the 4000' to 4300' elevation band. As with Still Creek it is assumed that the location of the current seeps and springs that form the headwaters of Camp Creek are associated with topography that was buried 1500 years ago.

Based on stream gradient (greater than 4%) and substrate (sand and gravel) Camp Creek above Government Camp is classified as a Rosgen A4 stream type. The A4 stream types typically have a high sediment supply which is combined with high energy streamflow to produce very high bedload sediment transport rates. The A4 stream types are generally unstable, with very steep rejuventated banks that contribute large quantities of sediment (Rosgen 1996).

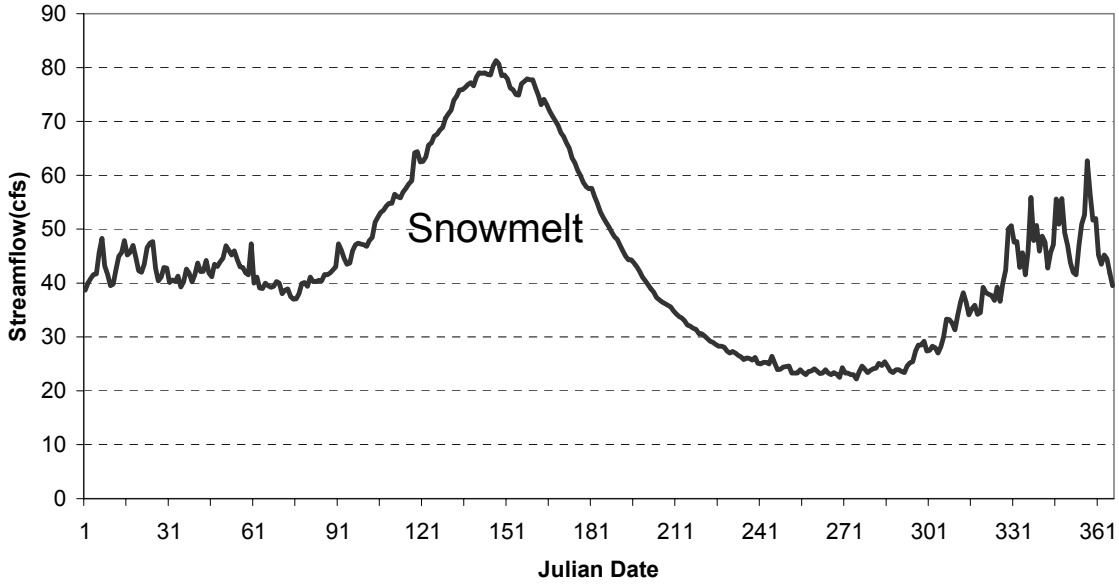
Camp Creek downstream of Multorpor Fen in the Ski Bowl Ski Area was classified as a Rosgen B3 channel type during the 1994 Camp Creek Stream Survey (USDA 1994). This channel type is moderately entrenched with channel gradients of 2-4%. The channel bed morphology is dominated by cobble materials and characterized by a series of rapids with irregular spaced scour pools. The channel materials are composed primarily of cobble with a few boulders, lesser amounts of gravel and sand. The bed and bank materials are stable and contribute only small quantities of sediment during runoff events.

Flow Regime

With the lowest elevation in the hydrologic planning area at 3650 and the highest elevation area at 6000 feet about 50% of the annual precipitation is contained in the snowpack based on data from adjacent SNOTEL sites. Based on the amount of precipitation associated with the snowpack a snowmelt dominated hydrograph would be expected for this area. Figure 1 details the mean daily values for the Salmon River stream gage at 3445 feet which has a period of record of 67 years and measures a watershed area of 8 square miles. This gage is approximately 1 mile east of Trillium lake and at approximately the same elevation as the

low end of the hydrologic analysis area. Figure 1 clearly details the influence of

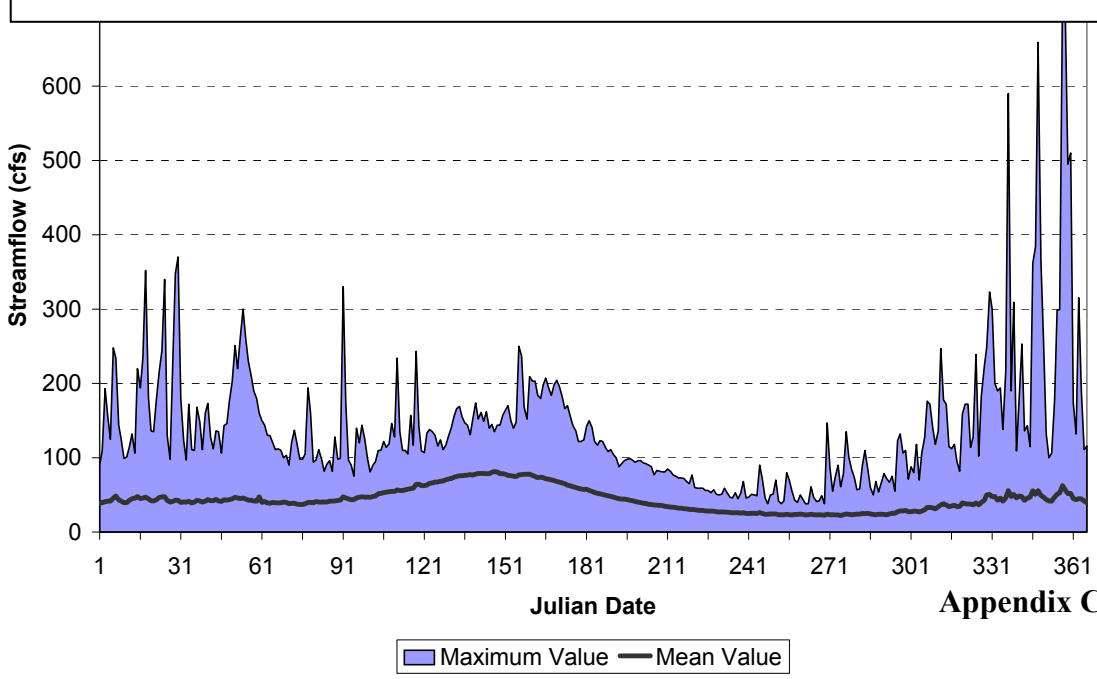
Figure 1 – Daily Mean Streamflows Salmon River at 3445 feet



the melting snowpack (staring in early April and peaking in late May) on the annual hydrograph. Baseflows at this site generally occur from mid July through mid November.

Figure 2 details the maximum daily streamflows for the 67 years of record for the Salmon River gage at 3445 feet. This figure details that the maximum streamflows occur from late November to early March. As detailed by Figure 2 the peak streamflow events are of short duration and peak and fall rapidly indicating that peak streamflows are associated with runoff from rapid snowmelt and rainfall during rain on snow events.

Figure 2 - Peak Streamflows Salmon River at 3445 Feet



Current streamflow data from Still Creek in the vicinity of Still Creek Campground indicates Still Creek differs from the Salmon River, as it is fed primarily by groundwater rather than direct run-off from the snowfield. Seepage from the upper snow fields travels through the near surface geology and expresses itself in the springs that provide the source of perennial flow (USDA, 2005)

Still Creek flow regime is "buffered" by the constant influx of groundwater. Pulses of surface runoff during rain events occur primarily when the ground surface becomes saturated and the ephemeral reaches of Still Creek carry water (USDA, 2005).

Within the hydrologic planning area there are water rights for approximately 15.8 cfs for various uses that are detailed in Table 4

Table 4 – Water Rights in the Hydrologic Analysis Area

Use Type	Total Water Rights (cfs)
Domestic	3.6
Fire Protection	0.1
Fish Culture	7.0
Other	5.1
Total	15.8

As a quick comparison the hydrologic planning area is approximately 8.6 square miles and the gaged area from the Salmon River Gage at 3445 feet is 8.0 miles so with the close proximity and similar areas it would seem appropriate to use the streamflow at the Salmon River gage as an approximation of the total streamflow from the hydrologic planning area. With mean base streamflows (assuming that existing water rights for Salmon River above the gage have been removed) at the Salmon River Gage around 25 cfs and existing water rights for 15.8 cfs in the hydrologic planning area it would appear approximately 60% of the baseflows are allocated.

Water Quality

Currently a Total Maximum Daily Load (TMDL) is being established for stream temperature in the Sandy Basin. The federal Clean Water Act requires DEQ to develop a plan with goals and pollution control targets for improving water quality in the watersheds where water quality standards are not met. DEQ is doing this by establishing TMDLs for each pollutant entering the water. In this case, heat is considered a pollutant because it raises water temperature. A TMDL describes the amount (load) of each pollutant a waterway can receive while maintaining compliance with water quality standards. An important step

in the TMDL process is determining how much stream heating results from natural sources and how much heat comes from human activities.

Oregon requires that a water temperature management plan (TMP) be developed and implemented by sources that contribute to stream heating. The TMP will identify the technologies, best management practices, and/or measures and approaches to be implemented by each source to limit stream heating. Stream heating and sedimentation from forestry activities will be controlled through implementation of measures in the state Forest Practices Act on private lands, the Western Oregon State Forests Management Plan in state forests, and federal Northwest Forest Plan on federal forestlands.

Within the hydrologic planning area there are two National Pollution Discharge Elimination System (NPDES) permits. Both permits are for activities that discharge into Camp Creek. H and P Development has a permit for Industrial Stormwater discharge associated with the Collins Lake Condominium Project and the Government Camp Sanitary District has a permit for Domestic Wastewater Treatment Facilities.

Sediment

The Watershed Analysis for the Zigzag Watershed (USDA, 1995)identifies moderate problems with turbidity and sediment associated with highway sanding and road surface erosion in both Still Creek and Camp Creek.

The 1996 Still Creek Stream Survey (USDA, 1996)details problems with sedimentation in the past near Still Creek Campground and in the upper portion of the Key Site Riparian area. These observations were validated with pebble counts from that survey that detail surface fines (material less than 6 mm) at 70% and 44% respectively in these reaches (the Mt Hood LRMP Standard is less than 20% surface fines).

The 1994 Stream Survey of Camp Creek (USDA, 1994) details high accumulations of silt and sand occurred throughout the stream with the highest accumulations observed adjacent to Camp Creek Campground (RM 1.7) and adjacent to Mirror lake Trailhead (RM 5.8). High accumulations of silt were also noted in areas adjacent to summer homes, bridge crossings, road landings, stream segments running along Highway 26, and the Ski Bowl recreation site. It should be noted that sedimentation was observed even in areas where bank erosion was not evident.

Furthermore, the stream survey states:

- Sedimentation could be attributed to heavy road sanding on Highway 26 as well as bank erosion. It was not possible to distinguish between sediment originating from road sanding or eroding stream banks.

- Another possible contributor to excess sediment levels may be the extensive use of Ski Bowl ski area and trails by mountain bikers in the summer months. High accumulations of sediment were noted in the stream adjacent to this recreation area.

- A concern relating to the condition of fish habitat in Camp Creek is the presence of high accumulations of silt and sandy substrate in the channel which may be decreasing the availability of ideal spawning gravels for both anadromous and resident populations.

Water Temperature

Camp Creek and Still Creek are identified by the Oregon Department of Environmental Quality as core cold water habitat for salmonids with a water temperature standard of the seven-day-average maximum temperature may not exceed 16.0 degrees Celsius (60.8 degrees Fahrenheit).

In the Watershed Analysis for the Zigzag Watershed (USDA, 1995) neither Camp Creek or Still Creek were identified with stream temperature problems. This was validated by temperatures taken during stream surveys.

In Still Creek temperatures taken during the 1998 survey (USDA, 1998) from July 6th to August 31st varied from a maximum of 15^{0}C at river mile 2.4, 2.7, and 3.3 to a minimum of 4^{0}C from river mile 14.0 to the end of the survey at river mile 14.4. Within the hydrologic analysis area (starting at approximately river mile 11.0) water temperatures varied from 4^{0}C upstream of river mile 14.0 to 9^{0}C at river mile 11.0.

Temperatures taken during the 1994 Camp Creek Stream Survey (USDA, 1994) from July 12th to August 22nd indicated a maximum of 12^{0}C in the vicinity of river mile 0.5 to a minimum of 8^{0}C in the area of Yokum Falls.

Groundwater Resources

There are approximately 324 acres of wetlands within the hydrologic analysis area based on the mapping from the National Wetlands Inventory (U.S. Fish and Wildlife Service 1998). Table 5 details acres by broad wetland classification.

Table 5 – Wetlands in the Hydrologic Analysis Area

Wetland Type	Acres
Scrub Shrub	114
Forested	110
Emergent	47
Lake- Unconsolidated Bottom	40
Unclassified	6
Unconsolidated Botton	5
Aquatic Bed	2
TOTAL	324

The wetlands are concentrated in three broad areas: headwaters of Trillium Lake, Multorpor Fen, and headwaters of Camp Creek. The 40 acre lake detailed in Table 5 is Trillium Lake.

Environmental Impacts

Table 6 – Summary of Activities and Impacts

Activity or Impact	Alt. 2	Alt. 3
Miles of Trail	9.6	11.3
Miles of Trail in Riparian Reserves	1.7	1.7
Acres of Clearing	19.2	23.6
Acres of Clearing Riparian Reserves	2.9	2.9
Feet of Trail in Wetlands	575	575
Acres of Clearing in Wetlands	0.2	0.2
Cubic Yards of Excavation	534	1911
Cubic Yards of Excavation in Riparian Reserves	534	534
Number of Stream Crossing	6	6
Stream Crossings on Fish Bearing Streams	2	2
Sediment Yield WEPP Model (pounds/year delivered to streams)	232	232
Sediment Yield Cumulative Effects Model used in Watershed Analysis (tons/year delivered to streams)	17.1	17.1
Acres of disturbance (bare soil)	1.91	2.42

Summary of Trail Contruction

As detailed in Table 7 the majority of the trail construction (92%) would be in the Zigzag Watershed.

Table 7 – Trail Construction by Subwatershed

Watershed	Subwatershed	Alt. 2 – Miles of Construction	% of Total	Alt. 3 – Miles of Construction	% of Total
Zigzag	Still Creek	0.9	9	2.5	22
Zigzag	Camp Creek	3.1	33	3.2	29
Zigzag	Little Zigzag Canyon	4.9	51	4.9	43
Salmon	Mud Creek	0.2	3	0.2	2
Salmon	West & East Fork Salmon River	0.4	5	0.4	4
		9.6	100	11.3	100

Summary of Trail Construction in Riparian Reserves

When trail construction within the Riparian Reserves is examined the majority of the construction is within the Camp Creek Subwatershed of the Zigzag Watershed.

Table 8 - Trail Construction in Riparian Reserves by Subwatershed

Watershed	Subwatershed	Alt. 2 – Miles of Construction	% of Total	Alt. 3 – Miles of Construction	% of Total
Zigzag	Camp Creek	1.3	76	1.3	76
Salmon	Mud Creek	0	2	0	2
Salmon	West & East Fork Salmon River	0.3	21	0.3	21
		1.7		1.7	

Summary of Trail Construction in Wetlands

There are 575 feet of trail construction planned in wetlands (as defined by the National Wetlands Inventory) with the majority of construction in the Camp Creek subwatershed. Both Alternative 2 and 3 have the same amount of construction in wetlands.

Table 9 – Trail Construction in Wetlands

Watershed	Subwatershed	Wetland Type	Feet of Construction	Percent of Total Construction
Zigzag	Camp Creek	Forested	417	73
Salmon	West & East Fork Salmon River	Forested	132	23
Salmon	West & East Fork Salmon River	Scrub Shrub	25	4
			575	100

There are 6 stream crossing associated with the project and 5 of these crossings are in the Camp Creek Subwatershed.

Hydrological Effects

Direct and Indirect Effects of Alternative I
Under the no action alternative there would be trail construction. Changes from the current condition are not anticipated to peak or base streamflow timing, duration, or magnitude, or water quality parameters of temperature and in-channel fine sediment

Direct and Indirect Effects of Alternatives II and III

Peak Streamflows
Based on the processes that affect peak streamflows and the associated methodologies for analysis, effects are analyzed at the subwatershed and fifth-

field watershed scale during a cumulative effects analysis. See the Aggregated Recovery Percent model discussion.

Base Streamflows
There are no direct effects anticipated to base streamflows because there are no water uses, impoundments or diversions associated with this project. Base streamflows can be influenced by the amount of disturbance to forest cover in a watershed so the potential effects of this project will be assessed in a base streamflow cumulative effects analysis

Temperature and Suspended Sediment
For Alternative II, 9.6 miles of trail would be constructed, 19.2 acres of vegetation would be cut and cleared, 534 cubic yards of material would be excavated, and 6 bridges would be constructed.

For Alternative III, 11.3 miles of trail would be constructed, 23.6 acres of vegetation would be cut and cleared, 1911 cubic yards of material would be excavated, and 6 bridges would be constructed.

Both Still Creek and Camp Creek within the hydrologic analysis area meet the water quality standard for temperature (seven-day-average maximum temperature may not exceed 16.0 degrees Celsius), but do not meet the Mt Hood Forest Plan standard for in-channel fine sediment (Spawning habitat (e.g. pool tailouts and glides) shall maintain less than 20 percent fine sediments (particles less than 6.0 millimeters in diameter) on an area weighted average. Mt Hood LRMP FW-097).

Designed into each alternative are soil and water protection measures or best management practices (BMPs) with the express purpose of limiting erosion and associated sediment yield to the streams and/or protecting vegetation that is providing stream shade. Through implementation of site specific BMPs this project is in compliance with the Clean Water Act. The BMPs are identified in Chapter 2.

It is the responsibility of the Forest Service as a Federal land management agency through implementation of the Clean Water Act (CWA), to protect and restore the quality of public waters under their jurisdiction. Protecting water quality is addressed in several sections of the CWA including sections 303, 313, and 319. BMPs are used to meet water quality standards (or water quality goals and objectives) under Section 319.

Current statewide Water Quality Standards state:

Pursuant to Memoranda of Agreement with the U.S. Forest Service and the Bureau of Land Management, water quality standards are expected to be met through the development and implementation of water quality restoration plans, best management, practices and aquatic conservation strategies. Where a

Federal Agency is a Designated Management Agency by the Department, implementation of these plans, practices and strategies is deemed compliance with this Division.

Stream Temperature

Stream temperatures can be affected by management activities that remove stream shade, alter channel structure, or alter the flow regime. This analysis will focus on changes in stream shade because there are no changes to channel structure or flow regime anticipated from the action alternatives.

Increased solar radiation has the potential to warm water as forest canopy vegetation is removed. While shading does not directly cool water temperatures, it reduces the amount of solar radiation reaching the water allowing for other processes, such as groundwater influx, to physically cool the water.

In the Oregon Coast Range and western Cascade Mountains riparian buffers of 100 feet or more have been reported to provide as much shade as undisturbed late successional/old-growth forests (Steinblums 1977).

In the Camp Creek Subwatershed activities within 100 feet of perennial streams under Alternatives 2 and 3 include 5 stream crossings that would remove approximately 100 feet of stream shade, and approximately 750 feet of trail construction between 75 and 100 feet away from a perennial tributary to Camp Creek.

Three of the stream crossings with bridges are associated with the Camp Creek Trail the streams in this area are narrow (approximately 3 to 4 feet wide wetted perimeter during summer low flows) with a shade layer provided by the shrubs in this area. The stands in this area are dense mid seral stands with 90-100% canopy closure. The streams in this area flow from north to south so the overstory shade will be removed on the east and west side of the stream and not the critical south side where the solar radiation is the strongest. The openings adjacent to the stream are narrow (20 feet) with mature vegetation remaining outside the cleared corridor that will provide stream shade. In addition streams in this area are feed by groundwater with stream temperatures estimated around 5^0C[1]. Based on these factors listed there are no water temperature impacts anticipated associated with these 3 stream crossings.

[1] According to Golder (2003), Still Creek at elevation 5,000 feet exhibits an average temperature of 3°C. At 3,600 feet, the average temperature is 6.8°C. Since water temperature in streams is cumulative and temperature typically becomes higher downstream, it can be deduced that the stream temperatures within the reaches in the hydrologic analysis area are between 3°C and 6.8°C (Golder, 1998). It is assumed that the groundwater source for both Still Creek and Camp Creek is the same so the stream temperatures would be similar.

The construction and clearing of approximately 750 feet of trail associated with the Camp Creek Trail and is 75 to 100 feet away from the stream. As with the bridge crossings the stream in this area is narrow with shrubs providing a layer of shade. The trees and shrubs between the trail clearing and the stream are dense mid seral stands with 90 to 100 percent canopy closure and will remain intact. Also as with the bridge crossings streams in this area fed by groundwater with temperatures estimated around 5^0C. Based on these factors there are no impacts anticipated to stream temperature associated with the trail clearing.

There are two bridge crossings on Camp Creek associated with the West Summit Fen Trail. In this area the stream is running east to west and the creek is about 11 feet wide (based on the 1994 stream survey) so the stream is not completely shaded by shrubs. The vegetation in this area is classified as late successional with associated large trees with large canopies. Due to the approach of this trail at the northern most bridge a 40 wide area will be cleared adjacent to the stream on the north side and and 20 wide area on the south side. On the southern most bridge 20 feet will be cleared on either side of the bridge. Stream temperature in this area is estimated at about 8^0C. Due to the limited area that is being cleared and the late successional vegetation in the area it is assumed that there will be little change in the amount of shade provided for Camp Creek so there will be no impacts anticipated to stream temperature.

There is one stream crossing with an associated bridge in the West and East Fork Salmon River Subwatershed on an unnamed tributary to Salmon River. The vegetation in this area is large conifers with approximately 85% canopy closure. The stream in this area is approximately 6 feet wide This trail is planned for bikes and hikers so there are no plans to cut any overstory vegetation to place the bridge. Based on fact that no overstory vegetation will be cut there are no impacts anticipated to stream shade.

In Channel Fine Sediment

The most important potential adverse impact of forest management activities on streams is often an increase in inorganic sediment. Large increases in the amount of sediment delivered to a stream channel can: greatly impair or even eliminate fish and aquatic invertebrate habitat, and alter the structure and width of streambanks and adjacent riparian zone (MacDonald, 1991)

Effectiveness of stream buffers at improving water quality adjacent to logging operations was studied in three watersheds in western Washington and found that 200 foot buffers would be effective to remove sediment in most situations if the buffer were measured from the edge of the floodplain (USDA, 1993).

Activities within 170 feet of streams (the riparian reserves in this area) for both action alternatives include 1.5 miles of trail construction, 2.5 acres of clearing, and 534 cubic yards of excavation. In order to quantify the sediment

yield to streams in the area the Water Erosion Prediction Project (WEPP) soil erosion model was used.

The WEPP model (Flanagan and Livingston 1995) is a physically-based soil erosion model that can provide estimates of soil erosion and sediment yield considering the specific soil, climate, ground cover, and topographic conditions. It was developed by an interagency group of scientists including the U.S. Department of Agriculture's Agricultural Research Service (ARS), Forest Service, and Natural Resources Conservation Service; and the U.S. Department of Interior's Bureau of Land Management and Geological Survey.

WEPP simulates the conditions that impact erosion--such as the amount of vegetation canopy, the surface residue, and the soil water content for every day in a multiple-year run. For each day that has a precipitation event, WEPP determines whether the event is rain or snow, and calculates the infiltration and runoff. If there is runoff, WEPP routes the runoff over the surface, calculating erosion or deposition rates for at least 100 points on the hillslope. It then calculates the average sediment yield from the hillslope.

All trail crossings of streams (perennial or intermittent) and areas where excavation of side slopes within 200 feet of a stream (where side slope exceeds 25% and a balanced cut and fill bench 15 wide is constructed) were modeled to determine sediment yield to streams.

Parameters used in WEPP Model Include

- Sandy loam soils with 5% rock cover
- Local climate for the Government Camp area (both precipitation and temperature)
- 63 percent cover for disturbed areas such as cut and fill slopes
- 80% shrub cover for all buffers (undisturbed areas)

The WEPP:Road module for used for all trail crossings of streams and the Disturbed WEPP module was used for cut and fill slopes on areas within 200 feet of a stream.

Table 10 – WEPP Sediment Yield

Activitiy	Erosion pounds per year	Yield to Stream pounds per year
Stream crossing stream to first drainage structure (one approach)	26.11	14.88
Stream crossing first to second drainage structure	24.14	1.08

(one approach)		
Cut and Fill Slope – Camp Creek Trail	1560	0
Cut and Fill Slope – West Summit Fen Trail	1440	40

Based on the sediment yield detailed in Table 10 there will be 200 pounds of sediment delivered to Camp Creek per year (5 stream crossings and West Summit Fen cut and fill slope) and 32 pounds per year delivered to the Salmon River (one stream crossing). For visualization purposes 200 pounds of sediment is equivalent to an area of 3 cubic feet.

Wetland Impacts

There are 575 feet of trail construction and 0.2 acres of clearing planning in wetlands under Alternatives 2 and 3. The Mt Hood LRMP gives direction that: Special aquatic habitat (e.g. alcoves, secondary and overflow channels, ponds and wetlands) and associated subsurface aquatic habitat (hyporheic zone) shall be maintained in a natural condition or enhanced in both quality and quantity (FW-104).

Special design criteria and associated best management practices that require trails within wetland areas to be constructed on puncheon structure or turnpiked to minimize impacts to the wetlands will be implemented. Trails will be designed to avoid wet areas when possible and to minimize the amount of overstory vegetation to be cleared in wetland areas.

Peak Streamflows – Cumulative Effects

This assessment was completed using the Aggregate Recovery Percent model (ARP). The ARP model was developed for use in the transient snow zone (2400-4800 feet). It provides a methodology for indexing the susceptibility of a watershed to increased peak flows from rain-on-snow events associated with management created openings in the canopy. This method assumes that the greatest likelihood for significant, long-term cumulative effects on forest hydrologic processes is caused by created openings in the canopy (from both timber harvest and from the existence of roads) that impact snow accumulation and snowmelt.

The ARP model was used to assess the proposed management alternative's potential affects on peak streamflows. This methodology was selected because:

- Some of the alternatives will create openings in the canopy that will affect snow accumulation and melt.
- Mt. Hood Forest Plan Standards and Guides are tied to this methodology.

The ARP model measures the percent of watershed hydrologic recovery based on managed stand age and a recovery curve developed for the Mt. Hood National Forest. This Forest recovery curve is a generalization of the percent of canopy cover and tree diameter expected at different ages of tree harvest plantations. The model assumes that a plantation has fully recovered its snow handling capabilities at 35 years of age. Because it does not predict the increase in peak flows, the ARP model is most useful when utilized in conjunction with information on watershed condition and sensitivity.

For this analysis it was assumed that activities that would reduce canopy closure below 70% in stands greater than 8 inches diameter at breast height (DBH) would have an affect on the ARP values. Harvest activities that did not reduce canopy closure of stands greater than 8 inches DBH below 70% were considered "ARP neutral."

A 35-year recovery curve was used to "grow" a plantation from seedlings to 8 inches DBH and 70% canopy closure.

Landscape areas analyzed included the affected subwatersheds and the fifth field watersheds as specified in the Mt. Hood Forest Plan Standards. For this project the created openings are in the Zigzag Watershed and the Still Creek, Camp

Creek, and Zigzag/Little Zigzag Subwatersheds. The ARP values were calculated twice for each land area: for all lands within an area, and for lands available for harvest within an area. Lands available for harvest include Forest Service Lands that are not classified as Wilderness.

In addition to this project other reasonably foreseeable projects included in the assessment are Timberline Express and Collins Lake Development

Table 11 -- Aggregate Recovery Percent Calculated Using All Lands Zigzag River Watershed

Index Year 2005

Area (All lands)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	97.0	97.0	97.0
Camp Creek 6th Field Subwatershed	93.6	93.5	93.5
Zigzag Little Zigzag Canyon 6th Field Subwatershed	99.1	98.9	98.9
Still Creek 6th Field Subwatershed	97.8	97.8	97.7

Table 12 -- Aggregate Recovery Percent Calculated Using Lands Available for Harvest Zigzag Watershed

Index Year 2005

Area (Lands Available for Harvest)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	96.7	96.7	96.6
Camp Creek 6th Field Subwatershed	95.3	95.2	95.2
Zigzag Little Zigzag Canyon 6th Field Subwatershed	99.1	98.9	98.91
Still Creek 6th Field Subwatershed	97.8	97.8	97.8

On a Forest-wide basis, ARP values above 65% have been recommended to prevent adverse effects associated with increased peakflows. Much of the available literature that discusses the relationship between harvest/road disturbance and peak flows implies a threshold of concern of 25% -- or ARP value of 75%. (USDA, 1990.)

As detailed by Tables 1 and 2 all of the affected watersheds and subwatersheds for all the alternatives are well above either the 65% or 75% threshold of concern.

Assessment of Compliance with Mt. Hood Forest Plan Standards

Applicable Standards

Mt. Hood Forest Plan Standards for Cumulative Watershed Effects

1. Vegetative management activities on National Forest System lands should be dispersed in time and space to minimize cumulative watershed effects. No more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time. (**FW-061, FW-062**)

    a. Within the 15 major drainages on the Forest, watershed impact areas shall not exceed 35 percent. (**FW-063**)

    b. Watershed impact areas at the subbasin or area analysis level should not exceed 35 percent. (**FW-064**)

2. Within selected "Special Emphasis Watersheds", watershed impact areas should not exceed the "thresholds of concern" (TOC) established for those individual watersheds (for this project Still Creek is the associated subwatershed with a TOC of 25%). (**FW-065**)

3. Cumulative effects analyses of management activities on water quality and stream channel stability (such as watershed impact analyses) shall include all lands in all ownerships within the watershed. (**FW-066**)

4. Where land ownerships are intermingled, timber harvest scheduling should be coordinated to prevent adverse cumulative effects. (**FW-067**)

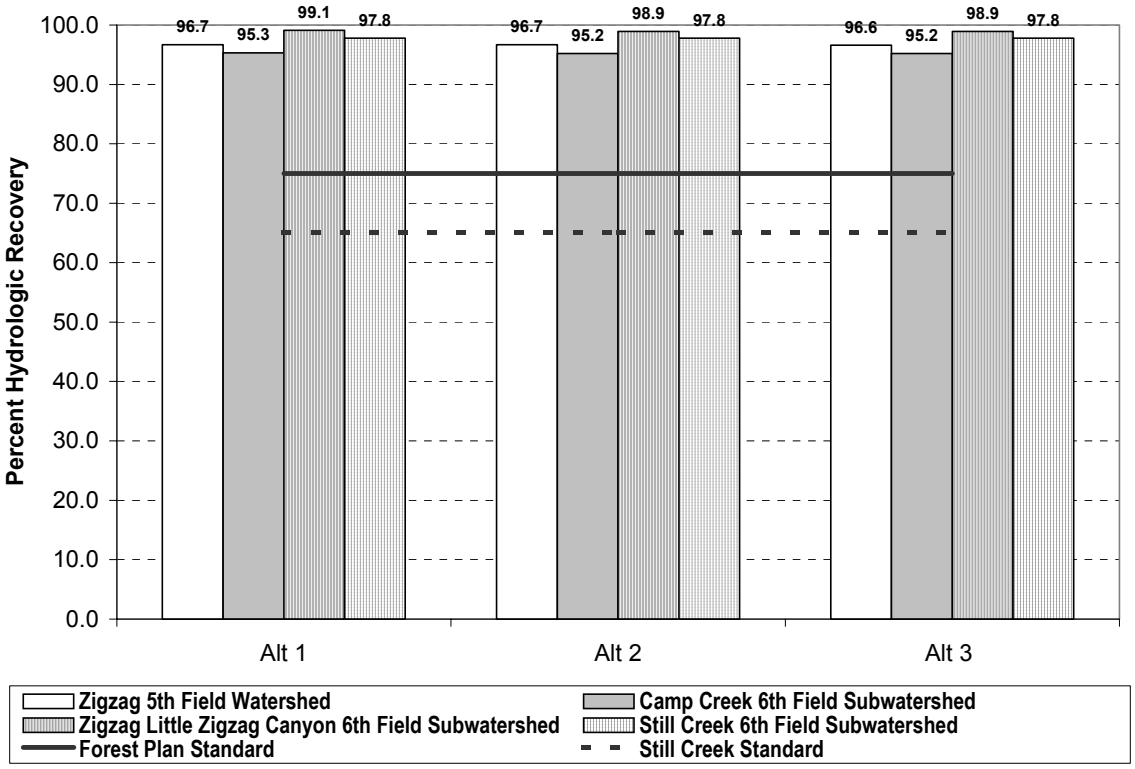
Results of Analysis

For this analysis activities considered included Timberline Express, Government Camp Activities (i.e. Collins Lake development), and Government Camp TIFF Trails.

Table 13 -- Watershed Impact Area Zigzag Watershed (Lands Available For Vegetative Manipulation) – Index Year 2005

Area (lands available for harvest)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	3.3	3.3	3.4
Camp Creek 6th Field Subwatershed	4.7	4.8	4.8
Zigzag Little Zigzag Canyon 6th Field Subwatershed	0.9	1.1	1.1
Still Creek 6th Field Subwatershed	2.2	2.2	2.2

Figure 3 – Hydrologic Recovery Zigzag Watershed (Lands Available For Vegetative Manipulation) – Index Year 2005



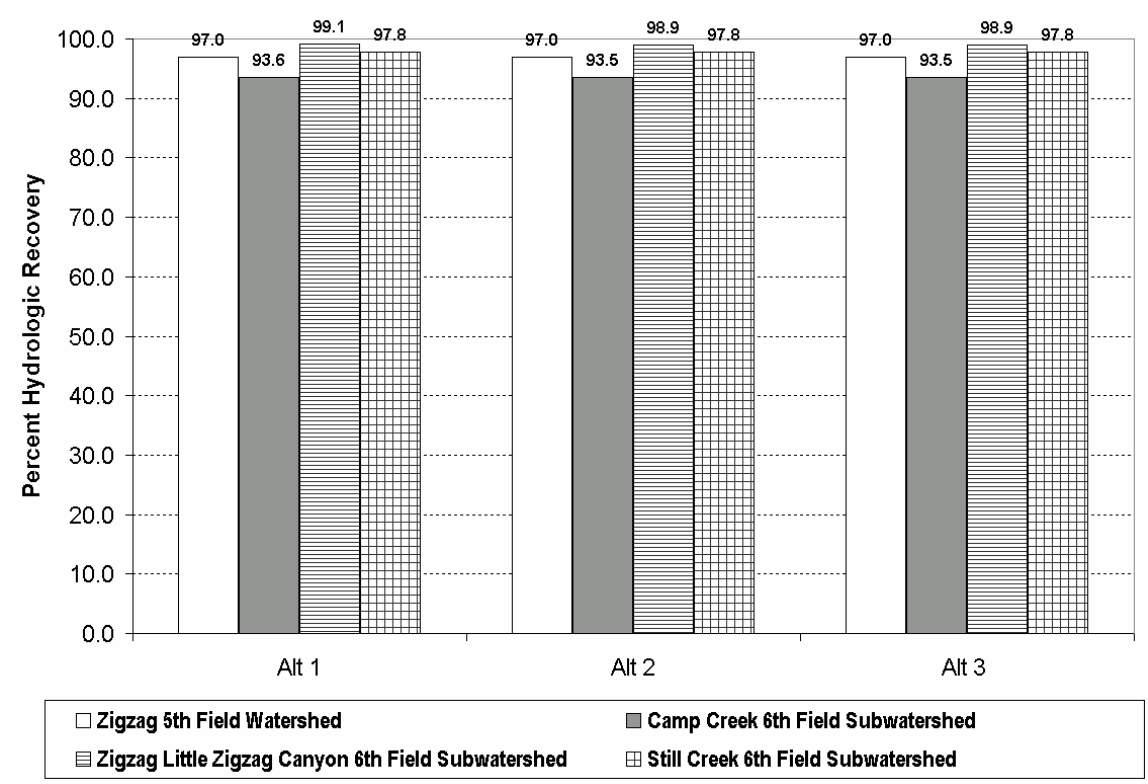
As detailed in Table 13 and Figure 3 all the associated watersheds and subwatersheds for all alternatives are well above the Forest Plan Standards for Watershed Impact Area (no more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time). FW-061, FW-062, FW-063, FW-064.

Still Creek Special Emphasis Watershed is also well above the established threshold of concern for watershed impact area of 25% with values at 2.2%. FW-065

Table 14 -- Watershed Impact Area (All Lands) Zigzag Watershed – Index Year 2005

Area (All lands)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	3.0	3.0	3.0
Camp Creek 6th Field Subwatershed	6.4	6.5	6.5
Zigzag Little Zigzag Canyon 6th Field Subwatershed	0.9	1.1	1.1
Still Creek 6th Field Subwatershed	2.2	2.2	2.2

Figure 4 – Hydrologic Recovery (All Lands) Zigzag Watershed – Index Year 2005



As detailed in Figure 4 and Table 11 the watershed impact area for all the associated watersheds and subwatersheds for all alternatives is very low (0.9% to 6.5%). This indicates that the associated watersheds and subwatersheds are not at risk for adverse cumulative affects associated with increased peak streamflows associated with rain on snow events.

In addition to potential increases in peak streamflows channel sensitivity was examined for the associated watersheds and subwatersheds to assess any affects in increased peak streamflows may have on the stream channel. For this analysis the Rosgen Channel types from the most recent stream surveys were used to assess channel sensitivity (Rosgen 1996). The results are presented in Table 15.

Table 15 Stream Channel Sensitivity

Area	Associated Stream Reach	Sensitivity to Disturbance	Sediment Supply	Streambank Erosion Potential
Camp Creek Subwatershed	Camp Crek @ confluence with Zigzag	Very High	Very High	Very High

	River			
Zigzag River Watershed	**Zigzag River @ confluence with Sandy River**	**Low**	**Low**	**Low**

Camp Creek at the confluence with the Zigzag River has a very high sensitivity to disturbance, a very high sediment potential, and a very high streambank erosion potential, however, this subwatershed also is 93.5% hydrologically recovered (or 6.5% of the watershed has been impacted by management activities). Even with the high sensitivity to disturbance in this subwatershed very little of the area disturbed so effects associated with bed and bank erosion from increased peak streamflows would not be expected.

Zigzag River at the confluence with the Sandy River has a low sensitivity to disturbance, a low sediment potential, and a low streambank erosion potential. With the associated watersheds and subwatersheds being over 90% hydrologically recovered with respect to increased peak streamflows from rain in snow events and the associated stream channels having a low sensitivity to disturbance the potential for adverse cumulative effects is low. (FW-066).

This conclusion is consistent with the associated Zigzag Watershed Analyses (USDA, 1995) that concluded that peak streamflows for the associated watersheds and subwatersheds are below the threshold of concern for adverse effects from peak streamflows associated with rain on snow events.

Base Streamflows – Cumulative Effects

Methods

The methodology used for this analysis was developed by SE Group for the Timberline Express DEIS. The methodology is detailed in the Appendices for that document in the Stream Flow Technical Report for the Timberline Express Proposal. The text describing the methodology is directly from that document.

It is well documented that removal of forest cover and creation of new impervious surfaces in a watershed increases available surface and shallow subsurface water, and can alter the flow regime of watershed (Dunne, T. and L. B. Leopold, 1978, Naiman, R.I. and R. E. Bilby, 1998). The dominant type of land cover change that affects surface runoff generation and streamflow conditions is large-scale timber harvest, which increases residual soil moisture due to the excess water that would normally be used by trees through processes called evapo-transpiration. The increased soil moisture promotes quicker development of surface water during rainstorms and additional shallow subsurface flow to streams in the treated area, especially in riparian areas adjacent to streams (Keppeler, 1998). Research indicates that timber harvest in small watersheds (60-300 acres) can increase annual water yield by as much as 26 to 43 percent in completely clear-cut watersheds and can increase annual water yield in partially cut watersheds by 3 to 15 percent (Harr et. al., 1979; Harr et. al. 1982; Keppeler, 1998). The construction of impervious surfaces (e.g. roads and parking lots) can also significantly increase stream flow by preventing rainfall from percolating into the soil, creating stormwater runoff that can contribute surface flow directly to streams (Wright et. al., 1990). According to research by Robert Ziemer, newly constructed roads occupying five percent of a watershed did not result in a detectable change in base flow or peak flow (Ziemer, 1981). However, a study conducted in the Alsea watershed concluded that new roads occupying 12 percent of a watershed resulted in increases in peak flow of roughly 19 percent (Harr et. al. 1975).

A thorough review of published literature was conducted in order to establish relationships between he size and type of watershed treatments (clear-cutting, road construction, etc.) and the measured effects on various stream flow parameters. Out of the 17 studies that were reviewed, seven were selected to be included in this model because they were conducted locally in Oregon and Northern California and typically involved watersheds with similar characteristics (climate, elevation, slope, etc.) to the two analysis watersheds for this EIS. The selected studies use the paired watershed technique to analyze the affects of watershed treatments, whereby two or more gauged watersheds that have similar characteristics are monitored for a long period of time (10 to 40 years) before and after watershed treatments are applied to all but one of the watersheds. The stream

gage data from the un-affected watershed is compared to the treated watersheds to see if the treatment had any measurable affect on the flow regime.

Since stream flow conditions can be analyzed in an infinite number of temporal and spatial scales, it is useful to describe changes in flow conditions at a few key recurrence intervals that are of most concern for a specific stream flow study. The concept of recurrence interval is commonly used to describe the statistical probability that a particular flow event will be exceeded in any given year. For the purposes of this analysis, the existing and proposed stream flow conditions were calculated and presented as annual low flow (base flow) and the 2-year peak flow. These specific flow rates were selected for analysis because, according to published literature, these are the flow rates most likey to be affected by land cover changes (Beschta et al., 2000; Burton, 1997; Keppeler, 1998; Hicks et al., 1991). Once the two flow rates were selected, the data contained in the seven selected studies was synthesized for each of the two flow rates for this analysis. The synthesized data was the plotted on a X, Y scatter plot and trend lines were fit to the data with the percentage of the watershed treated on the X axis, and the percent change in the specific flow rate on the Y axis (see Charts 1 and 2).

Chart 1. Changes to Low Flow Discharge Due to Watershed Treatments.

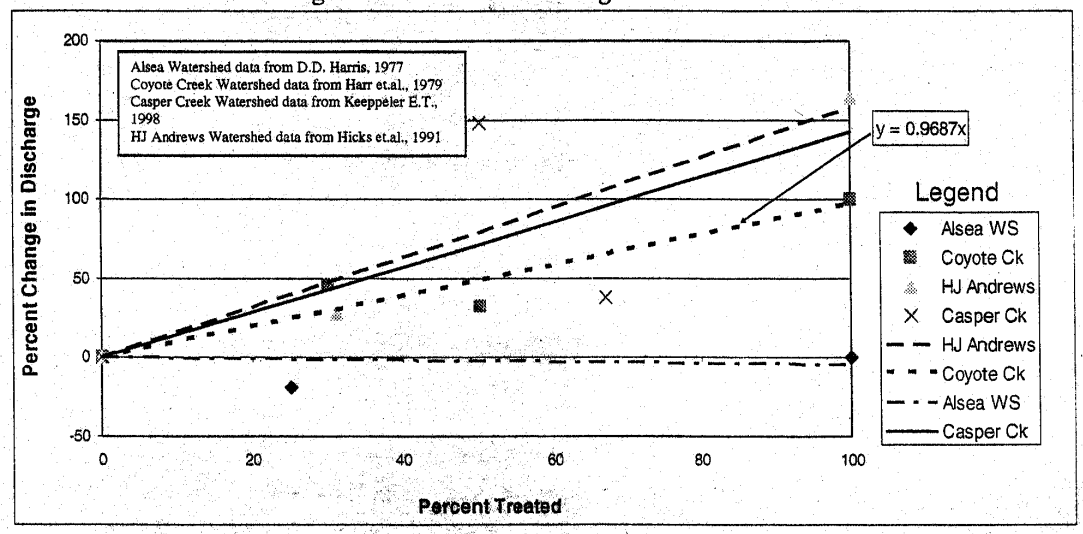
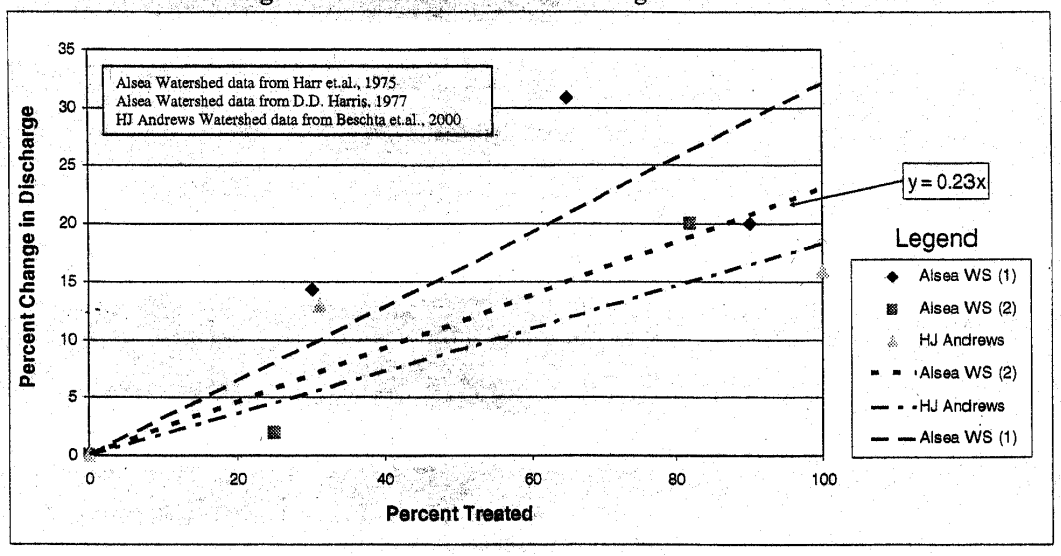


Chart 2. Changes to 2-Year Peak Flow Discharge Due to Watershed Treatments



The most representative study for each parameter was chosen based on the characteristics of the watersheds in the study, the location of the trend line relative to the trend lines from other studies, and the fit of the trend line to the data. Once a trend line was selected for each flow rate, an equation was developed to describe the equation so that the percent change in flow rate (discharge) could be calculated under any treatment scenario. The selected trend line is identified in each table with by an arrow that connects the equation to the trend line (see Charts 1 and 2). Next, the estimated change in flow for the selected return interval (low flow or 2-year peak flow) calculated by determining the percentage of the

watershed proposed for treatment and inserting the treatment percentage into the appropriate equation. For the purposes of this analysis, the treated area in the watershed for existing and proposed conditions was determined by calculating the total area of modified herbaceous, modified shrub, and developed land cover using GIS software and dividing that value by the area of the watershed to be analyzed. Using this stream flow model combined with GIS datasets that contain vegetation or generalized land cover information, comparative estimates of potential changes to low flow and 2-year peak flow from historic or proposed treatments can be made.

Results

Using the hydrologically disturbed area from the peak streamflow cumulative effects analysis as detailed in Table 16 increases in base streamflows were calculated and are detailed in Table 17.

Table 16 – Hydrologically Disturbed Area

Area (All lands)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	3.0	3.0	3.0
Camp Creek 6th Field Subwatershed	6.4	6.5	6.5
Zigzag Little Zigzag Canyon 6th Field Subwatershed	0.9	1.1	1.1
Still Creek 6th Field Subwatershed	2.2	2.2	2.2

Table 17 – Changes in Base Streamflow from an Undisturbed Condition

Area (All lands)	Alt 1	Alt 2	Alt 3
Zigzag 5th Field Watershed	2.9	2.9	2.9
Camp Creek 6th Field Subwatershed	6.2	6.3	6.3
Zigzag Little Zigzag Canyon 6th Field Subwatershed	0.9	1.1	1.1
Still Creek 6th Field Subwatershed	2.1	2.1	2.1

Overall baseflows are predicted to increase about 6% in the Camp Creek subwatershed and 3% in the Zigzag subwatershed. Based on baseflow values from the Salmon River gage at 3445 feet this would result in a 0.6 cfs increase in Camp Creek and a 5.5 cfs increase in the Zigzag River. Implementation of the Government Camp TIFF Trails Project would result in a 0.03 cfs increase in base streamflow in the Camp Creek subwatershed.

The increases associated with all activities are slight and are not expected to have an impact to beneficial uses. The increases associated with implementation of the Government Camp TIFF Trails Project are extremely slight and most likely would not be detectable.

Surface Erosion Cumulative Effects Analysis

This Surface Erosion Cumulative Effects Analysis is based on the analysis that was completed for the Zigzag Watershed Analysis (USDA, 1995) and has been modified to assess the affected subwatersheds and associated watershed from this project. Potential increases in sediment yield associated with the implementation of the Government Camp TIFF Trails Project were incorporated.

Natural rates of surface erosion in forested watersheds is measured to be quite low (Swanson, F. and G. Grant, 1982; USEPA-USDA Forest Service, 1980). Surface erosion in the watershed is tied to processes which disturb soil litter and duff cover. The series of high intensity fires (1901, 1908, 1910, 1915, 1933/1934) that burned over large acreage's of the watershed would have generated a sediment pulse each winter following the initial disturbance. Surface erosion would have returned to post fire rates as surface covering vegetation became reestablished.

More recent disturbances to soil cover include roads, timber harvest, site preparation, and recreational uses. These disturbances create chronic, long-term supplies of sediment within the watershed. Methods used to evaluate the altered surface erosion rates within the watershed closely follow those described in the Washington Forest Practices Board Manual: Standard Methodology for Conducting Watershed Analysis (DNR, 1993). In addition to sediment production from surface erosion, sand applications to snow-covered highway surfaces are a chronic source of sediment in the watershed. Actual rates of sand application were taken directly from Oregon Department of Tranportation records.

Only those sediment sources with high potential for delivery were considered in this process. Sediment production that was not within the delivery zone to perennial streams was not calculated for this analysis.

For this analysis Camp Creek Subwatershed and the Camp Creek Subwatershed upstream of the Camp Creek in the Laurel Hill area (key depositional reach) were modeled. Even though there were slight amounts of sediment generated in other subwatersheds only Camp Creek is analyzed because of it's existing condition and much higher (3 to 8 times higher) predicted sediment production.

Results

Potential sediment from highway sanding was computed using actual application rates obtained from the Oregon Department of Transportation.

Modeled estimates of sediment transport considered roads within 300 feet horizontal distance of streams within the watershed. While steep slopes along

Highway 26 receiving highway sand within 300 feet slope distance may be effective in delivering sand to streams, they were not considered in the estimates.

The highway is within 300 feet (horizontal) of Camp Creek for 1.67 miles, and within 300 feet (slope distance) for an additional mile.

The largest road cut and fill slopes within the watershed are those along Highway 26 adjacent to Camp Creek. Many of these cut and fill slopes are poorly vegetated and/or covered with residual highway sand during the fall and spring.

Table 18 - Road Related Sediment Contribution

SUBWATERSHED	TOTAL ROAD MILES	ROAD DENSITY (miles per square mile)	MILES WITHIN 300 FEET OF STREAMS	ESTIMATED ROAD SEDIMENT (Tons/Year)	HIGHWAY SANDING SEDIMENT (Tons/Year)
Camp Creek	20.77	2.14	4.61	285.87	2102.14

Recreation

Recreation activities within the watershed can also contribute to increased potential for surface erosion. Unvegetated ski slopes, campgrounds, and some trails can contribute to surface erosion. While the amount is significantly lower than that from roads and highway sanding, recreation sites are often directly adjacent to water resources. Table 19 summarizes the estimated sediment contribution of recreational related sediment.

Table 19 -- Potential Sediment Contribution from Recreation and Harvest Activities

SUBWATERSHED	SUBWATERSHED ACRES	RECREATION (tons/year)	HARVEST (tons/year)
Camp Creek	6225	8.53	0.00

Table 20 presents the modeled sediment yield associated with implementation of the Government Camp TIFF Trails Project. Both alternatives 2 and 3 yield the same amount of sediment.

Table 20 – Potential Sediment Yield from Government Camp TIFF Trails

Alternative	Projected Sediment Yield From New Trails (tons/year)
1	0
2	13.29
3	13.29

It should be notes that the sediment yield in Table 20 is much higher than that presented in the Environmental Impacts Section of the Environmental Assessment. This is because this model assumes that all trails within 200 feet of streams will contribute sediment to the stream. The site specific modeling completed in the Environmental Impacts Section actually models each trail and cut and fill slope so it is assumed that the site specific modeling is more accurate. However, the associated sediment yield predicted with the cumulative effects modeling is useful for comparison purposes to other sediment sources in the subwatershed.

Table 21 -- Summary of Estimated Sediment Yield (tons/year)

SUBWATERSHED	ROAD SEDIMENT	HIGHWAY SANDING	RECREATION	TIFF TRAILS	TOTAL
Camp Creek	285.87	2102.14	8.53	13.29	2409.84

Implementation of the Government Camp TIFF Trails Project will result in a 0.5% increase in sediment yield at the subwatershed level.

Sediment Deposition

The consideration of sediment production at the subwatershed level can assist in the identification of priorities for mitigation and restoration. In order to assess the potential impact on in-channel habitat, low gradient reaches which provide habitat for aquatic species of concern were identified. As the following map displays, depositional reaches are often associated with stream junctions.

Key depositional reaches were identified to simplify the analysis. For these key reaches, cumulative sediment delivery and deposition to those points was computed. Fine sediment delivery to stream channels and transport to depositional reaches within the watershed can alter substrate competition important to aquatic species (invertebrates, amphibians, fish, and plants).

Figure 5 -- Key Depositional Reaches within the Watershed

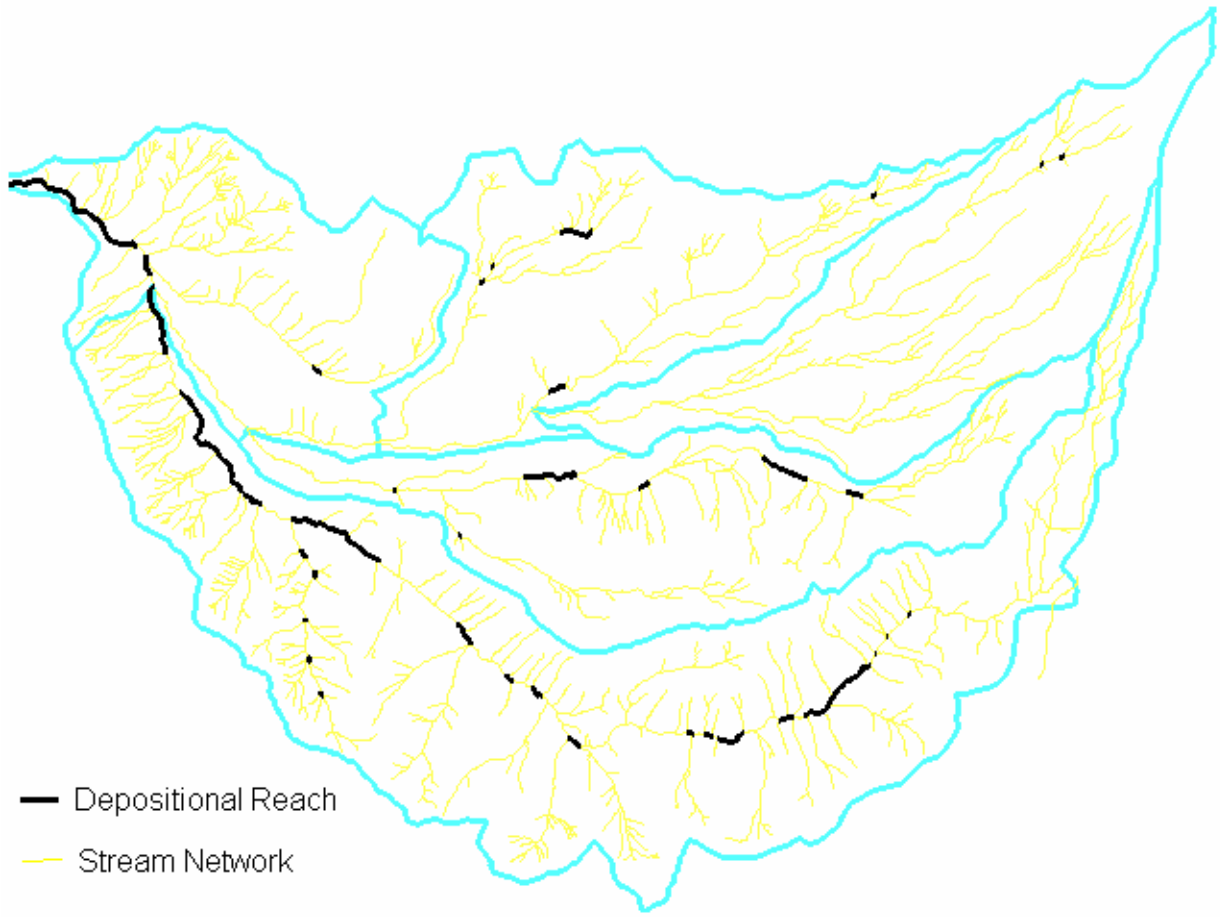
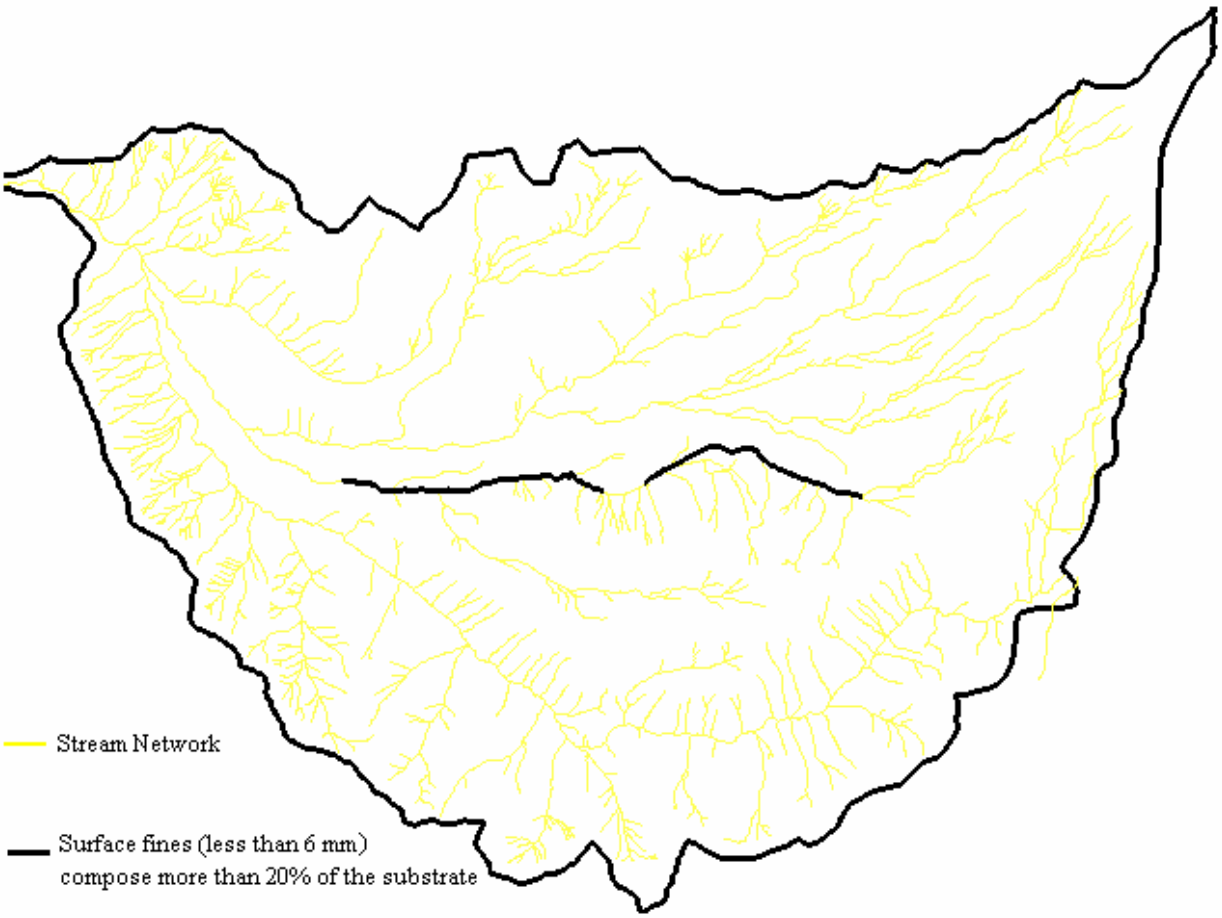


Table 22 -- Cumulative Sediment Deposition at Key Reaches

KEY DEPOSITIONAL REACH	ACRES	ESTIMATED SEDIMENT DEPOSITION (Tons/Year)
Camp Creek below Laurel Hill	3782	544.77

Implementation of the Government Camp TIFF Trails Project is projected to increase sediment yield by 2% at the key depositional reach.

Figure 6 - Depositional Reaches Where Fine Sediment Levels Exceed Forest Plan Standards



Conclusions Regarding Sediment

Implementation of the Government Camp TIFF Trails project will is projected to increase sediment yield in the subwatershed by 0.5% and at the key depositional reach by 2%. Even though Camp Creek currently exceeds the standards for fine sediment both of these increases are very small and are not expected to affect the beneficial uses in this area.

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