Appendix P

Hydrology Specialist Report

Resource: Hydrology

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Past Management Actions

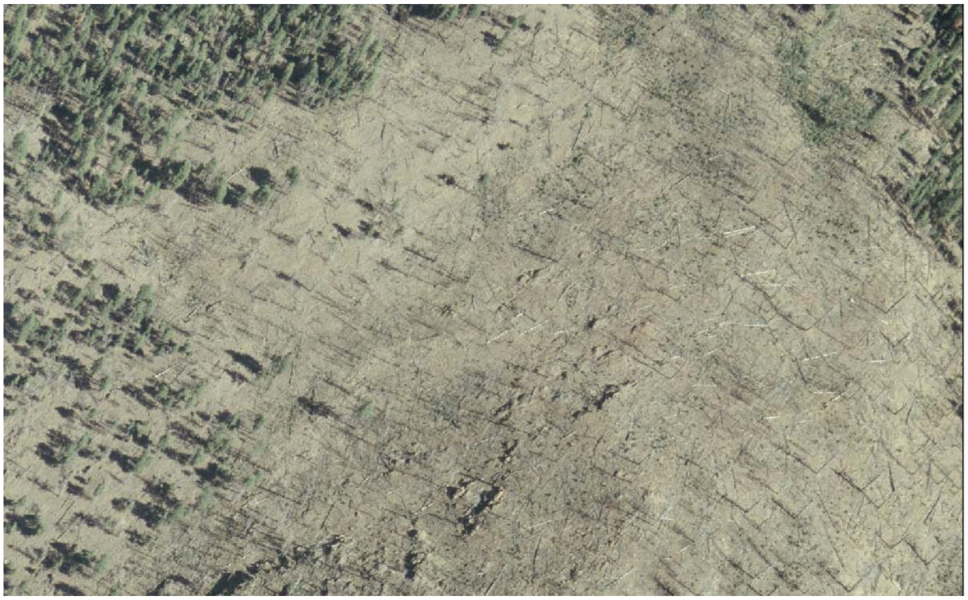
Historic mining and logging, wildfire, and wildfire suppression have disturbed the Little Canyon Mountain Watersheds.

WATERSHED COVER

Uncharacteristically dense watershed cover has altered the project area hydrology by intercepting and evaporating snow and other precipitation. Prior to fire suppresison, this water would have been absorbed by soils and the forest floor. As a result, less water is available for uptake by vegetation or streamflow. A century of wildfire suppression has changed the ponderosa pine and dry mixed conifer ecosystem on Little Canyon Mountain. These areas, which historically experienced frequent low intensity surface fires, have accumulated living trees and debris. The stands are densely stocked with small diameter trees. In addition, the accumulation of fuels set up conditions for a stand replacement fire (see Effects of No-Action Alternative).

While watershed cover has been most obviously modified by fire suppression, wildfire and harvest activities have removed some over-story conifers. Recent burning and harvest on the South side of Little Canyon Mountain have removed some of the dense cover and shifted interception and evaporation processes towards historic levels. In 1999, a fire burned 119 acres thereby altering a portion of the watershed cover in the south side drainage. The fire severity varied and the burn created a “patchy” appearance across the landscape. That winter, the area was logged. The logging operation created a large landing that has since been planted with pine seedlings. Between ten and twenty percent of the trees of each diameter class were left standing. Some green trees were thinned, and seedlings were planted to restore watershed cover. (personal communication, Vidourek 2002) However, some areas are still overstocked with small diameter trees.

In 1987, a stand replacing fire burned 132 acres (5% of the watershed) in the headwaters of Little Pine Creek watershed. It is likely that this severe fire resulted in erosion and sediment delivery into Little Pine Creek that continued for several years after the fire. The burned areas still appear deforested on 2002 aerial photography. Today, the area is beginning to vegetated with grass, but still lacks the large conifer overstory of the surrounding forest (see August 2002 photo below).



MINING AND SETTLEMENT

Mining and settlement activities removed riparian vegetation along Canyon Creek and Little Pine Creek. Historic photos and survey notes indicate that Canyon Creek was heavily vegetated with riparian vegetation including willows and cottonwoods in the late 1800s. Some of the cottonwoods were cut down to build houses.

A surveyor's note from 1880 states: "This line runs along the north slope of Canyon City Mountain. The timber has all been cut off and there is a dense growth of brush and small pine. The country is very rough, rocky, mountainous and broken, Soil 2nd rate." (Robb 1880, south side section 1). This would indicate that trees in the Whiskey Gulch watershed were harvested in the late 1880s to provide wood for the mills located on Big Pine Creek and especially for the mill upstream from Canyon City. Today, little evidence of this activity remains. The extent of the disturbance to the watershed is difficult to quantify, but important to note. Any resultant ground disturbance is overshadowed by the disturbance created by the mining activities. It is difficult to estimate how current the watershed is affected by this historic removal of 12" to 18" tree removed from the site.

Photos document the hydraulic mining wastes entering Canyon Creek. Portions of Canyon Creek near Canyon City were dredged. When Highway 395 was build next to Canyon Creek it caused the creek to become further entrenched. This important highway still constricts Canyon Creek. As Canyon City has aged, Canon Creek has become increasingly confined and prohibited from accessing its flood plain. However, flooding does occasionally afflict the residents of Canyon City.

Beginning around 1862, Little Pine Creek was hydraulically mined. This involved creating ditches to wash gold-bearing gravels through a sluice. This method was especially destructive to stream channels and floodplains. Water was ditched from Dog Creek and Little Pine Creek to the site of the placer. This increased the stream power flowing down Little Pine Creek and the other drainages where the water was used. When the stream channel had been exhausted of gold, the vegetation of the floodplain was removed.   The miners worked their way back and forth across the floodplain sifting through the sediments for gold. The finer soil would have been washed down stream and large cobbles were piled to the side as tailings (LaLande, Jeffrey M. 1985). These are still evident today in Little Pine Creek. Tailing piles are scattered up the valley on Little Pine Creek's flood plains. The later use of monitors to hose down the slopes created steep headwalls along the streams.

Existing Environment/Conditions in the Watersheds

This project straddles the Dog Creek and Lower Canyon Creek 6th field sub watersheds, as delineated by the Regional Ecosystem Office. The BLM project area land encompasses less than 5% of the Dog Creek sub watershed and less than 9% of the Lower Canyon Creek sub watershed. The Dog Creek 6th field sub watershed contains several pure watersheds, including the watershed of the perennial Little Pine Creek. BLM project area lands make up 25% of the Little Pine Creek Watershed. The other pure watershed in the project area with perennial flow is the 200-acre Whiskey Gulch Watershed. The BLM project area lands make up almost 92% of this small spring-fed watershed.

Little Pine Creek and Canyon Creek are listed on the 303d list of affected waters for the parameter of temperature. Canyon Creek's history of dredging and current entrenchment limits it from reaching its potential geometry. By observation, Little Pine Creek water temperatures on the project site were fairly cool during the summer of 2002. The stream is well shaded by young encroaching conifers and a diverse set of riparian vegetation. Dogwood, water birch, willow, gooseberry, snowberry, and alder shade the stream along the higher gradient reaches. In the few places where sunlight reaches the forest floor, Herbaceous vegetation is establishing along the lower gradient meanders, where sunlight reaches the forest floor. At lower elevations near the confluence with the John Day River, aerial photography indicates that riparian vegetation and stream flow are lacking. Once again, historic mining activities have disturbed the natural floodplain and sediment regime.

WATER RIGHTS

Both Little Pine Creek Watershed and Lower Canyon Creek Watershed have considerable withdrawal of water for the surrounding towns and rural communities. Water is used in reservoirs and diverted from streams. The Little Pine Creek watershed contains water rights for 12 small reservoirs. The water stored in these reservoirs is minimal, totaling less than seven acre-feet. The total rate of water permitted for diversion has the potential to divert a significant portion of the flow of Little Pine Creek, particularly in the summer. (see table below)

Little Pine Creek Watershed Point of Diversions Summarized by Beneficial Use	
Beneficial Use	Diversion Rate in cfs
Domestic non-commericial	0.01
Domestic	0.015
Irrigation	4.53
Livestock	0.005
Mining	4.75
Grand Total	9.31

Mining diversions total more than half of the rate of diversion for the watershed, but are rarely used. Decreed irrigation rights (older than 1909) take precedent over mining rights, and this limits the water actually available for mining during the irrigation season. Irrigation use (4.5cfs) constitutes a much greater portion of the water diverted in the summer, when base flows are low. Water Availability Reports for the Watershed ID (WID) that contains Little Pine Creek and several similar tributaries (WID 30620117) show that water is available for further allocation December through June at the 50% exceedence level. The 50% exceedence level means that a value is equaled or exceeded 50% of the time. In this case that means that half of the time, water would be available for further allocation to water rights in the specified months. At the 80% exceedence level, water is only available December, January, April and May. On Little Pine Creek, water rights are consistently regulated back to 1865 water rights by the OWRD. Shutoffs occur in mid to late July of almost every year. About one cfs is even ditched over from Dog Creek in an effort to increase the amount of water available for irrigation. Mid to late season, Little Pine Creek's water deficiency approaches 2 cfs (Kelly Rice, personal communication 2002).

Monthly average natural stream flows at the mouth of Canyon Creek equal or exceed about 20 cfs in July one out of two years. The summary table below indicates that the permitted amount of water diverted surpasses the summer low flow levels for Canyon Creek. Nonetheless, actual use is less than the maximum allowable diversion rate. In addition, diversion for mining is infrequent.

Canyon Creek Watershed Point of Diversions Summarized by Beneficial Use

Beneficial Use	Diversion Rate in cfs
Fire Protection	0.02
Domestic lawns and gardens	0.03
Storage	0.17
Domestic	0.39
Wildlife	0.40
Livestock	0.62
Irrigation and Domestic	3.00
Irrigation	4.19
Municipal	5.16
Mining	13.33
Supplemental Irrigation	20.02
Grand Total	47.33

Similar Water Availability Reports for Canyon Creek (WID#205) indicate that at the 50% exceedence level, water is only available further allocation from March through June. At the 80% exceedence level, water from Canyon Creek would only be available for further allocation in April and May.

Existing Environment/Condition in the Project Area

The project area encompasses the headwaters of several perennial and intermittent stream channels. Whiskey Gulch, Canyon Creek, Byrams Gulch, Long Gulch, Rich Gulch, Little Pine Creek and several unnamed drainages drain the north side of Little Canyon Mountain and empty out onto the alluvial fans and lower hills of the John Day River Valley. Whiskey Gulch is a first order stream that flows northwest to its confluence with Canyon Creek on the South end of Canyon City. At the top of the mountain, ephemeral draws grade to intermittent channels. Gradients range from upwards of 50 percent slope near the top of Little Canyon Mountain to 15 to 20 percent slope in the lower reaches. Springs provide perennial flow for the last 3000 feet of Whiskey Gulch. Long Gulch drains a narrow sliver of the project area to the North and flows into Canyon Creek near Grant Union High School.

Little Pine Creek is a second order perennial stream originating on Canyon Mountain in the Strawberry Wilderness Area and draining into the mainstem John Day River at River Mile 250. The Bankfull flow of Little Pine Creek at the lower boundary of this project area is estimated at 45 cfs. This estimate is based on field measurements and regional hydraulic geometry equations (Castro and Jackson, 2001). Annual runoff is estimated at 10 inches. This is based on annual water yield of gaged watersheds in the area.

Within the upstream portion of the project area Little Pine Creek is characterized by a narrow valley bottom. As in many of Little Canyon Mountain's watersheds, tailing piles of large cobble are scattered along Little Pine Creek's flood plains. Where mining tailings are mounded on Little Pine Creek's floodplain, the stream cuts an incised channel through the headwalls and piles of tailings. In entrenched channels, the depth, velocity, and erosive energy of flows are higher. These relatively straight sections consist of a series of step pools confined in a deep channel and can be described as a G3 stream type (Rosgen, 1996). Between these steeper, entrenched reaches, the channel flattens out. The stream has begun to establish a meander pattern with a narrow floodplain. The channel is shallower and accesses its floodplain more frequently. These flatter reaches match the description of a B4 stream type (Rosgen, 1996).

Within the downstream end of the project area Little Pine Creek valley widens into an alluvial setting. Mining tailings completely bury the stream channel for several hundred feet. Summer surface flows disappear and flow subsurface under the tailings. It is evident from scour on top of the tailings that Little Pine Creek flows over these tailings in the winter months.

Little Pine Creek has a limited ability to move the mining tailings strewn across its floodplain. The Riffle Stability Index (RSI) (Kappesser, 2002) is a measure of the percent of materials that move from one riffle to the next during frequent flood flow events. A bar sample RSI for Little Pine Creek indicates that 55 mm particles move in relatively frequent flood flow events (smaller than a Bankfull event). Similarly, the hydraulic calculations applied to Shield's curve indicate that 80 mm particles will be at the threshold of motion at bankfull flow. These particles can be described as very coarse gravel (55mm) to very small cobble (80mm). The mining tailings strewn across Little Pine Creek's floodplain are large cobbles (180mm). Therefore, this disrupted stream channel flood flows are not capable of transporting and sorting the tailing materials in order to re-establish meanders across the valley bottom.

Little Pine Creek's stream channel conditions were compared to Overholt Creek, a less disturbed system located in a wilderness. In order to measure the baseline conditions, surveyed reaches were installed in both creeks. Overholt Creek, located on the Malhuer National Forest, has similar aspect, precipitation, vegetation, geology, slope, and fire return intervals. Overholt Creek's watershed is mostly within a wilderness area, and can be characterized as relatively undisturbed by human activity. Overholt and Little Pine Creeks are B4 channel types. These similarities provide context for discussion of the differences in the measured channel form and bed materials between Overholt and Little Pine Creek (Appendix A and Appendix B).

The substrate of Little Pine Creek is much more embedded and therefore more immobile than the substrate of the Overholt Creek reference reach. This is based on visual observations and on the RSI of each reach. Ninety percent of the substrate at Overholt Creek moved during frequent flood flow events, while only fifty percent of the substrate at Little Pine Creek was mobile during frequent flood flow events. Fines in Little Pine Creek are embedding the substrate and hindering the natural transport of coarse gravel and large cobble. The substrate of Little Pine Creek has become armored with large substrate that is cemented in by fines. The fines produced by this watershed are being transported through the incised sections of stream channel and deposited in the pools and point bars of the meander reaches. (Yang, 1996)

Pebble Counts were used to compare the percent fines between Little Pine Creek and Overholt Creek reference reaches. These two reaches were hydrologically similar. Fines are defined as particles less than 2 mm at their intermediate axis. The Overholt Creek substrate consists of 15% fines, while the Little Pine Creek substrate consists of more than 19% fines. Based on a 2 x 2 contingency table, we can be over 95% sure that Little Pine Creek has significantly more fines than Overholt Creek. (Conover, W.J. 1980)

Little Pine Creek is visibly deficient in large wood when compared to the Overholt reference streams. It is likely that many mature conifers were removed from Little Pine Creek during mining activities. Overholt Creek is capable of floating mature trees, but would usually move materials that are broken into logs and pieces. Overholt creek had several log jams and large wood was obviously responsible for the pattern and process of the stream. Whole trees move infrequently. A 25 to 50 year flood event is required for whole trees to move. When these pieces of wood catch behind a root bole, they create log jams. The log jams create sites that accumulate gravel and pond water. These jams provide channel complexity and enrich the floodplain. During floods, this confined B channel will come out of its bank and spread into the forest. Forested riparian areas slow the floodwaters and trap floating organic material that later contributes to soil development. (BLM, 1998)

GROUND WATER

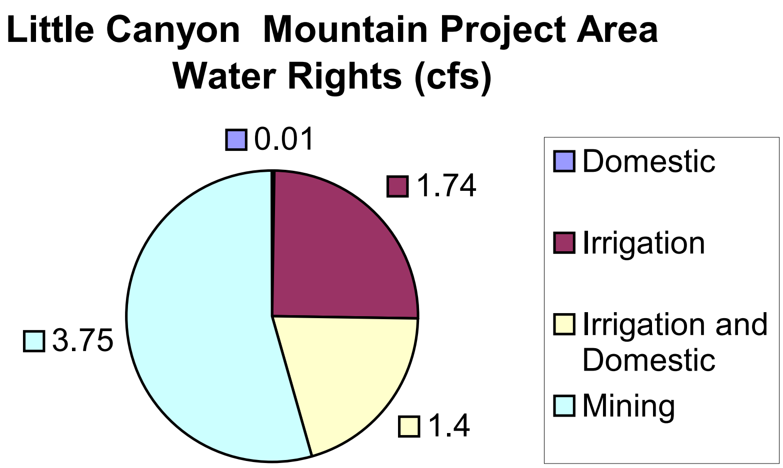
Based on well logs in section 6, a confined aquifer exists on the alluvial slopes on the North end of the project area. Well logs indicate that at approximately 170ft below the surface two clay layers bound a layer of gravelly soil. This creates an artesian condition for ground water. Several alternating layers of clay and gravels continue below this point. Surface springs may be related to other alternating clay and gravel layers in the alluvium.

WATER RIGHTS

Little Canyon Mountain is peppered with water rights (See table in Appendix C). The beneficial uses for the water include domestic, stock water, irrigation, and municipal beneficial uses. Fifteen permitted water right point of diversions are within the project area, and three others are close by. Canyon City has a municipal water right in Whiskey Gulch. Canyon City Officials, however, indicated that Canyon City has not used this source for at least 20 years, and they have no plans to use it in the future. Currently, Byram Gulch supplies water for Canyon City. The water is transported to the City via a pipeline running north along the west project area boundary. (Bremner, personal communication 2002)

Water rights in existence at the time that the Federal Land Policy Management Act (1976) was enacted do not require right-of-way agreements to pass the water over public land to the place of use on private land. Water rights acquired after 1976, however, do need right-of-way agreements. Only five of the fifteen water rights in the project area have priority dates later than 1976. Three of the five are for mining activities and the other two are for very small amounts of irrigation and domestic use.

Little Pine Creek is the most effected by project area diversions. Diversions from the Little Pine Creek or its tributaries total 6.9 cfs. The beneficial uses for the water are distributed as described in the table below:



Water withdrawals from the other drainages in the project area are minimal. Rich Gulch contains three diversions for irrigation and domestic water that total a little over half a cfs. Whiskey Gulch point-of-diversions total less than one sixth of a cfs and are mainly for domestic use.

ROADS

Road densities within the project area are the highest along the Northern and Eastern portion of the project area. The types of existing roads are detailed below.

Existing Roads	Miles
ATV Trail	4.2
Local Haul	1.0
Local Unimproved	23.2
Main Haul	2.4
Total	31

Roads have three primary interactions with water: interception, concentration, and rerouting. Roads intercept rainfall directly on the road surface and road cutbanks. They also intercept subsurface water moving down the hillslope. Roads concentrate flow, either on the surface or in an adjacent ditch or channel. Finally, they divert or reroute water from its more natural flowpaths. Many hydrologic and geomorphic consequences result from these interactions.

Interception of surface and subsurface flow concentrates and diverts water into ditches, gullies, and channels. Road systems increase the density of streams in the landscape.

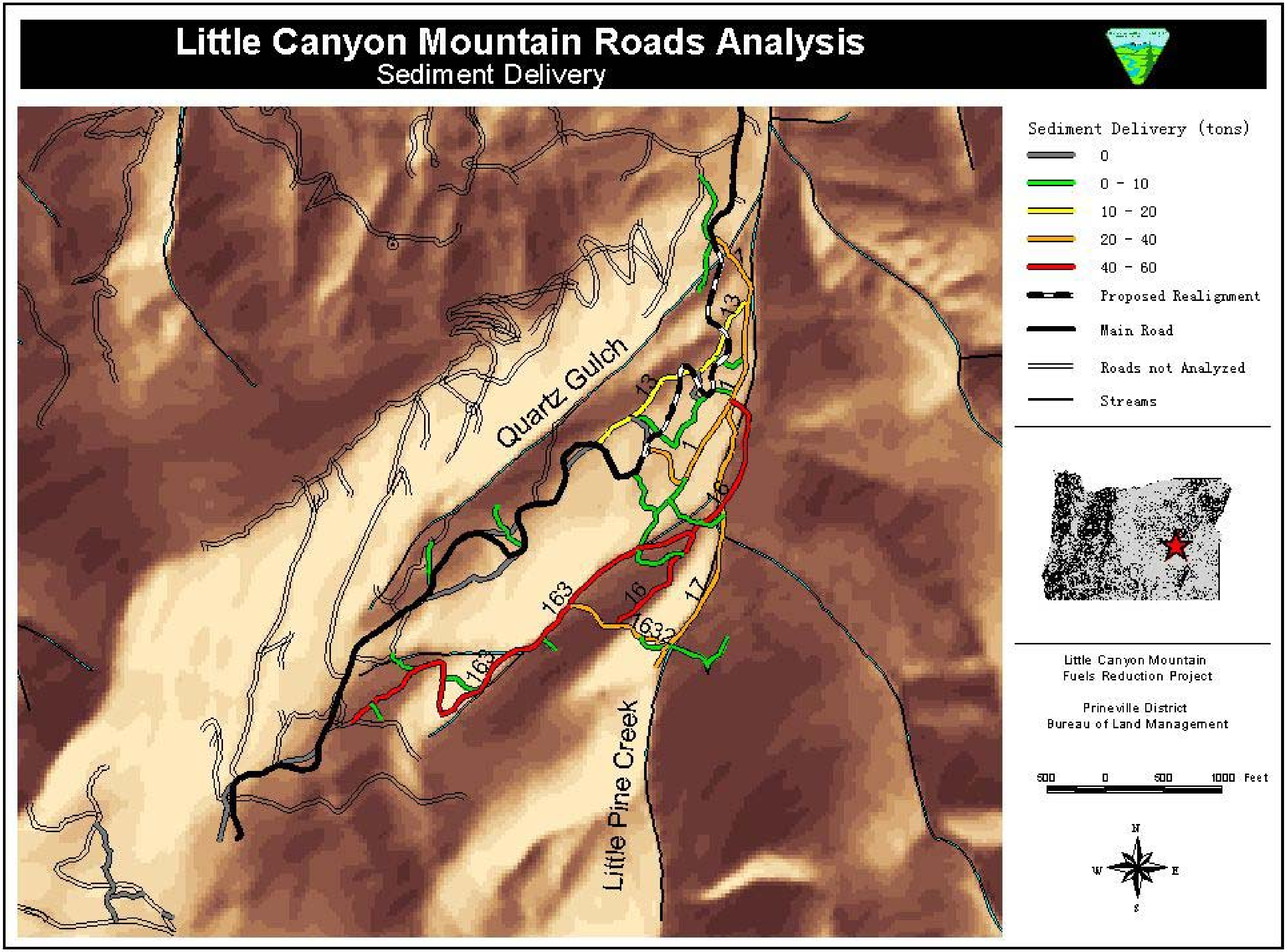
This extension of the drainage network changes the amount of time required for water to enter a stream channel. As a result, the timing of peak flows and the shape of the hydrograph are altered. In a study in Idaho, peak stormflow magnitude increased in one basin but decreased in another after road building. The study authors attribute this effect to subsurface flow interception by roads and desynchronization of delivery of water to the basin outlet. (King, 1984) (Wemple, 1996a) (Wemple, 1996b) (Herman, 2000)

On Little Canyon Mountain, roads are located on the Northeastern portion of the project area. Most of the roads on the Northern toe slope are relatively flat and the native surface material is comprised of stable, rocky soil types. As we move up towards the Northern face of the mountain, the erosive potential of the roads increases due to an increase in slope. Several ditches circumnavigate the face of Little Canyon Mountain from East to West. Two of the ditches are still in use today, while the third is a historic ditch. These ditches, like roads, disrupt hillslope processes by capturing and re-route some of the surface and subsurface runoff from the up slope. The ditches are breached at several locations. Breaching is most frequent at road crossings or areas where it can be used for "mud bogging." The breached areas have created small gullies and eroded areas of the hillslope.

The other area where erosion from roads has been identified is in the Upper Little Pine Creek Watershed. Here, roads traverse right through the riparian area and cross stream channels 20 times. A few drainage dips have been installed on the main haul road, but their spacing, size and the rutting by traffic on the road reduce their effectiveness. One road traverses directly up a spring fed stream channel for ¼ of a mile. The ¾ square mile area around quartz gulch has a road density of over 15 miles per square mile. This high concentration of roads in and near the stream channel is likely contributing to the high level of fines in Little Pine Creek discussed earlier. The average annual sediment yield of each road segment proposed for closure in the Upper Little Pine Creek Watershed was modeled using WEPP. Based on 30 years of simulated precipitation, the sediment yield is quantified below.

Road Number	Sediment (tons)
16	56.953
163	54.263
1	34.028
17	31.644
1632	23.797
13	15.905
15	9.355
1631	9.070
11	8.153
20	7.868
173	7.122
16321	4.519
14	4.511
12	3.374
1634	2.347
162	2.240
1635	2.082
172	1.286
1636	0.718
1633	0.498
25	0.258
18	0.114
23	0.058
19	0.000
21	0.000
22	0.000
24	0.000
26	0.000
27	0.000
28	0.000
151	0.000
271	0.000
282	0.000

Stream Receiving Sediment from Roads	Tons
Little Pine Creek (LPC)	186.57
Quartz Gulch	18.91
Left Bank trib to LPC after Quartz Gulch	74.68
Grand Total	280.16



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Brief (1 page or less) Existing Environment/Condition

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The project area, which historically experienced frequent low intensity surface fires, has accumulated living trees and debris. This dense watershed cover alters the historic hydrology by intercepting and evaporating snow and other precipitation, which would normally be absorbed by soils and the forest floor. While watershed cover has been most obviously modified by fire suppression, wildfire and harvest activities have removed some over-story conifers. It is likely that severe fire resulted in erosion and sediment delivery into Little Pine Creek for several years after the fire.

Several ditches circumnavigate Little Canyon Mountain. These ditches disrupt hillslope processes by capturing and re-route some of the surface and subsurface runoff from the up slope areas. The breached areas have created small gullies and eroded areas of the hillslope.

The effects of historic mining are still evident today. Fine soils have been washed down stream and large cobbles are piled along the floodplain. Tailing piles are scattered up the valley on Little Pine Creek's flood plains. The later use of monitors to hose down the slopes created steep headwalls along the project area streams. Hydraulic mining wastes were washed into Canyon Creek. Canyon creek has become entrenched due to dredging and other land use activities. A major highway and development of Canyon City constricts Canyon Creek making it increasingly confined and prohibited from accessing its floodplain.

Within the upstream portion of the project area, a narrow valley bottom characterizes Little Pine Creek. As in many of Little Canyon Mountain's watersheds, tailing piles of large cobble are scattered along Little Pine Creek's flood plains. Where mining tailings are mounded on Little Pine Creek's floodplain, the stream cuts an incised channel through the headwalls and piles of tailings. These relatively straight sections consist of a series of step pools confined in a deep channel. Between these steeper reaches, the stream has begun to establish a meander pattern with a narrow floodplain. The channel is shallower and accesses its floodplain more frequently. These flatter reaches match the description of a B4 stream type (Rosgen, 1996). Within the downstream end of the project area Little Pine Creek valley widens into an alluvial setting. Summer surface flows disappear and flow subsurface under the mining tailings

The substrate of Little Pine Creek is much more embedded and therefore more immobile than the substrate of the Overholt Creek reference reach. The substrate of Little Pine Creek has become armored with large substrate that is cemented in by fines. There are significantly more fines in Little Pine Creek than in the Overholt Reference Creek. Little Pine Creek is visibly deficient in large wood when compared to the Overholt reference stream.

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Both Little Pine Creek Watershed and Lower Canyon Creek Watershed have considerable withdrawal of water for the surrounding towns and rural communities. Permitted withdrawals exceed natural summer low flows in both watersheds. This limits the amount of water available for riparian area vegetation and aquatic life. Ground water flows between alternating lenses of clay and gravels in section 6.

Environmental Effects of No Management Actions- Direct Effects

Fire affects many components of the hydrologic cycle. A high intensity fire on Little Canyon Mountain would reduce infiltration, decrease interception, increase evapo-transporation, and disrupt the subsurface movement of water. A high intensity fire on Little Canyon Mountain would decrease condition of the already disturbed watersheds.

"*Watershed condition* is a subjective term to indicate the health (status) of a watershed in terms of its hydrologic function and soil productivity. The hydrologic function of a watershed relates to its ability to receive and process precipitation into stream flow without ecosystem deterioration. Soil productivity reflects the capabilities of a watershed for supporting sustained plant growth and plant communities, or the natural sequences of plant communities. " (Debano and others, 1998)

WATERSHED EROSION

Indirect Effects on Resource

The risk of catastrophic wildfire is not reduced by the no action alternative. In the event of a severe wildfire, hillslope erosion rates would increase. However, this is a fairly stable, rocky set of soils, so hillslope erosion is not likely to be in the form of mass movement. Watersheds severely denuded by fire are often vulnerable to accelerated rates of soil erosion and, therefore, can yield large, but often variable, amounts of post fire sediment. Sedimentation in dryland environments is often viewed as an unsteady process. This episodic sediment transport process is attributed to erosion from infrequent big storms. This makes it difficult to determine a "normal rate" of sedimentation on either undisturbed or burned watersheds. (Debano, 1998)

1 year

Sediment yields are likely to increase. Robichaud and Brown (1999) studied erosion rates after a wildfire in Eastern Oregon Ponderosa Pine. They found that first-year erosion rates after a wildfire ranged from 0.5 to 1.1 tons per acre. These rates decreased by an order of magnitude the second year of the study.

5 years

It is likely that sediment yields from the watersheds would still be higher than pre-fire levels. Low severity burned area would have re-vegetated. After three years the sediment yields in the low severity burn areas would have returned to normal levels (Debano, 1996).

10 years

A study following a wildfire in Ponderosa pine, reported sediment yields from a moderately to severely burned watershed did not return to normal until 7 and 14 years, respectively (Debano, 1996). These values represent a range for the amount of time required for vegetation establishment to return erosion to more natural levels.

INFILTRATION

Rainfall in the undisturbed forest rarely produces overland flow that results solely from limited infiltration capacity (Anderson, 1976). The forests on the mined areas of Little Canyon Mountain are not “undisturbed.” Nonetheless, the forest has produced thick duff layers from the mid to upper elevations which is excellent for infiltration.

Fire destroys accumulated forest floor material and vegetation. This alters infiltration by exposing soils to raindrop impact or creating water repellent conditions (DeBano and others 1998) (McNabb, 1989). Burn severity (see table below) determines the extent to which on-site resources are affected by a fire. The component of burn severity that results in the most damage to soils and watersheds is duration. Fast moving fires in fine fuels, such as grass may be intense in terms of energy released per unit area, but do not transfer the same amounts of heat to the forest floor, mineral soil, or soil organisms as do slow moving fires in moderate to heavy fuels. The impacts of slow moving, high intensity fires on soils are much more severe.

Table 1—Burn severity classification based on postfire appearances of litter and soil and soil temperature profiles (Hungerford 1996, DeBano et al. 1998).

	Burn Severity		
Soil and Litter Parameter	**Low**	**Moderate**	**High**
Litter	Scorched, Charred, Consumed	Consumed	Consumed
Duff	Intact, Surface Char	Deep Char, Consumed	Consumed
Woody Debris - Small	Partly Consumed, Charred	Consumed	Consumed
Woody Debris - Logs	Charred	Charred	Consumed, Deeply Charred
Ash Color	Black	Light Colored	Reddish, Orange
Mineral Soil	Not Changed	Not Changed	Altered Structure, Porosity, etc
Soil Temp. at 0.4 in (10 mm)	<120 °F (<50 °C)	210-390 °F (100-200 °C)	>480 °F (>250 °C)
Soil Organism Lethal Temp.	To 0.4 in (10 mm)	To 2 in (50 mm)	To 6 in (160 mm)

One severe effect due to high intensity fires is hydrophobic soils. Hydrophobic soils repel water. They are the result of a waxy substance that is derived from plant material burned during a hot fire. The waxy substance penetrates into the soil as a gas and solidifies after it cools, forming a way coating around soil particles. Not all wildfires produce hydrophobic soils. The following four factors can increase the likelihood of site soils becoming hydrophobic: a thick layer of plant litter prior to the fire, coarse textured soils, volcanic soils, prolonged periods of intense heat and high intensity surface and ground fires (Soil Quality Institute, 2000) (McNabb, 1989).

Little Canyon Mountain's soils are not coarse. However, McNabb observed water repellency in loam or finer textured soils in Oregon. Broadcast burning increased water repellency of the surface soil. This effect was short lived, and water repellency decreased to a level where it no longer differed significantly from the unburned plots after the first fall rains. This water repellency may be related to dehydration of organic matter in the soil during light broadcast burns, and therefore it may not appear across the entire landscape of a severe fire. (McNabb, 1989)

INTERCEPTION

Most of the vegetative canopy and litter can be lost completely in severe fires. This results in comparatively less interception of precipitation. The interception of precipitation is important in preventing soil erosion and balancing the amount of runoff. Intercepted precipitation can follow several courses in the watersheds depending on antecedent condition, temperature, and vegetation type. The amount of precipitation that is intercepted varied depending on the vegetative watershed cover. On Little Canyon Mountain, juniper dominates portions of the project area on the West facing slopes and scattered areas to the North. In juniper-dominated sites, the juniper decreases the amount of water available to the understory of bunch grasses by intercepting precipitation and then funneling the water through stemflow down the trunck. This stemflow moves water directly to the base of the tree for the juniper roots to use. Other tree species on the site also intercept precipitaiton. Ponderosa and fir cover a majority of the project area. In Idaho, Ponderosa Pine Intercept 24 % of the snowfall. (Connaughton, 1935) Helvely found that Ponderosa Pine intercepts 0.14 inches per inch of inch of precipitation, while Doug fir's dense needles capture .25 inches per inch of precipitation. (Helvey, 1971) However, these calculated values are not absolute.

Several critical conditions determine whether a forested area or clear-cut area will have higher outputs of precipitation to soil (see table below). (Berris and Harrr, 1987)

Precipitation Traveling through Forested Area to the Underlying Soil				
Forest Condition	(1)Temperatures at or above 0 C	(2) Rainfall occurs when snow is in the forest Canopy	(3) Rainfall rates (<3mm/hr) *without* snow in the canopy	(4) Rainfall rates (> 5mm/hr) *with* snow in forest canopy
Forested Areas	Higher	Higher	Depends on snow patchiness,	Lower once the snow's water holding

			water content and density	capacity is reached
Clear-cut	Lower	Lower	Depends on snow patchiness, water content and density	Higher once the snow's water holding capacity is reached

For Little Canyon Mountain, the rainfall from a 2 year 6 hour rainfall would meet condition (3) where water output would vary depending on the patchiness, water content and density of the snow. At higher elevations, the areas deforested by wildfire would accumulate more snow pack, and thus these sites would produce more water than before a wildfire. At lower elevations, snow would melt off the open areas deforested by wildfire and the forested areas would contribute more water. Condition (4) may be met infrequently because the canopy at Little Canyon Mountain rarely maintains its intercepted snow, especially at lower elevations.

EFFECTS ON STREAM FLOW

When a wildfire removes watershed cover, annual runoff increses, and the annual hydrograph changes. The timing of precipitation influences the annual hydrographs in the Little Canyon Mountain Area. Accumulated snow and moisture frozen in the ground during late fall and winter melts in the spring, causing greater streamflow in the spring. Peak flows in the Blue Mountain region occur in the spring (Hydrologic Process Identification for Oregon, 2001). Sometimes two periods of high streamflow can be experienced. One in the fall when the rainy season starts and before cold weather changes the precipitation to snow and a second peak when the snow melts.

Low flows generally occur at the end of the summer season. During the dry summers, a month or more may pass without appreciable precipitation. During the summer, precipitation is considerably less than evapotranspiration. As a result of this patter or low rainfall and relatively high evapotranspiration stresses, vegetation has an important influence on summer streamflow. (Rothacher, 1970)

A high intensity fire can alter the seasonal distribution of runoff by reducing cover and by decreasing evapotranspiration. During summer rain events, the reduced timber basal area and litter cover reduces infiltration or interception. As a result, more water leaves the watershed as runoff and less water leaves the watershed as evapotranpiration. A dramatic example of these effects were documented in the Entiat experimental watersheds after a wildfire. After the severe fire, daily oscillations due to diurnal patterns of transpiration were virtually eliminated because vegetation along stream channels was destroyed and was no longer transpiring water. In addition, there was a gradual increase in flow rate to a level above the pre-fire values. (Bernt 1971)

As previously mentioned, snowmelt generates spring runoff in this area. The energy available to either ripen a snowpack or to melt snow can be summed up in an energy budget. The energy available for snowmelt is the sum of incoming shortwave solar radiation, the radiation lost due to albedo of the snow pack, incoming longwave radiation, outgoing longwave radiation, convective transfer of sensible heat, conduction at the snow-gound interface, and the flow of latent heat from rain or fog. There is a trade off between shortwave and longwave radiation at a snow pack surface as the forest cover changes. As forest cover increases, the solar radiation at the snow pack surface is reduced greatly; the longwave radiation loss from the snow pack is reduced and the longwave gain component from the canopy increases. Between 15 and 30% canopy cover, net radiation at the snowpack surface is at a minimum; net radiation is highest at 0% cover, but it is also relatively high at dense forest canopy conditions because of the much higher net long wave component. (Brooks and others, 1997)

A severe wildfire would effectively take the watershed cover to 0%. This would result in the highest net radiation for melting snowpack and increased water available at the soil surface for runoff. Wildfires also create large openings (greater than 10 m^2) similar to those created by a clearcut. In these openings, the snowpack experiences maximum losses to sublimation. The snowpack in these open areas also tends to melt earlier than in surrounding forested areas. (Troendle 1984) The study of the burn in the Entiat experimental watershed found that runoff occurred one to two months earlier following a severe wildfire. (Helvey 1974) (Helvey 1980)

Campbell and others, 1977, compared the runoff efficiencies (ROE), or the percent of runoff to precipitation, in a Ponderosa Pine dominated moderately burned watershed to a severely burned watershed. Compared to the moderately burned watershed, the ROE of the severely burned watershed was 51 percent less in the snowmelt periods. In the snowmelt period, the lower tree density of the severely burned watershed allowed more of the snowpack to be lost to evaporation. As a result, less stormflow occurred than on the more shaded, moderately burned watershed.

The ROE on the severely burned watershed was 357 percent greater than a moderately burned watershed when the precipitation input was rain. The difference during rainfall events was attributed to lower tree density, reduced litter cover, and hydrophobic soil resulting in lower evapotranpiration losses on the severly burned watersheds than on the moderately burned watersheds. Burned watersheds generally respond to rainfall faster than unburned watersheds, producing more "flash floods" (Anderson, 1976).

In Eastern Oregon, rain-on-snow events historically result in large runoff events, as in 1964 and 1996. Interception of snowfall in the forest canopy seems insufficient to have a major effect on the rate of water input to soils during the crucial peak of the rain on snow input events. Maximum streamflows do not occur at the beginning of rain-on-snow events when melting of intercepted snow would have its greatest relative contribution. (Berris and Harr, 1987) Therefore, it is not anticipated that changes in the forest cover would effect streamflow values in rain-on-snow events at Little Canyon Mountain. The change in forest cover would, however, change the annual runoff and increase peak flows.

Destruction of vegetation and reductions in litter accumulation and other decomposed organic matter by fire can lead to increased peak flows. Several studies describe the possible effects of a wildfire on peak flows. A wildfire in the mostly ponderosa pine Entiat watershed in Washington produced a 42 percent increase in water yield the first post fire year when compared to part of the watershed which had been control burned (Helvey 1980). An analysis of snowmelt floods on watersheds on the east side of the Cascade Mountains showed that peak flows would be expected to increase by about 11% when one half of a watershed was burned or poorly stocked. (Anderson and Hobba 1959, in Anderson 1976) Clear cut areas experience changes in peak flows that are similar to burned areas. Some clear cut areas experienced 90% increases in peak flows when fall storms generated the runoff, while other similar clearcut areas experienced 28% increases in peak flows. (CITATION???) Peak flows in Ponderosa Pine in Eastern Oregon can be expected to increase approximately 45% after a wildfire (Anderson 1976, in Debano, 1998). Peak flows in the Entiat experientam watershed in Washington experienced approximately double peak flows after a severe wildfire burned the mostly Ponerosa Pine watershed. (Helvey 1974) (Helvey 1980) Harris and Hubbard (1983) found forest cover to be an important factor in calculating regional flood-frequency equations for this Northeast region. Using these regional equations, bi-annual peak flows are predicted to increase %12. The hundred-year flood would increase %18. The hundred-year flood calculated value has a standard error of plus %101 or minus %50, but it is useful for comparison with the management alternatives. (See Appendix D)

In examining effects of forest management on peak flows, principle concerns include the extent and geographic pattern of areas of open vegetation conditions where snow may accumulate to greater depths and melt more rapidly than in forested areas (Cissel and others, 1998). The north facing watersheds of Little Canyon Mountain accumulate more snow. Therefore, these areas would experience the largest effects on peak flows if forest canopy were removed by wildfire.

Removal of the forest canopy and duff also increases the annual water yield. As a general rule, we expect the increase in annual water yield to be roughly proportional to the percent of the drainage clearcut (Rothatcher, 1970) or burned. Approximately 25% of Little Pine Creek is within this project area, but more than half of the watershed is stocked with fuel that would burn intensely in a wildfire. Helvey and others found increased annual runoff on burned watershed in the Entiat experimental watershed in Washington after it was severely burned. ((Helvey 1974) (Helvey 1980)

Annual water yield increases due to vegetation manipulation vary depending on the type of vegetation. Mixed Conifer Forests (Ponderosa and Douglas Fir) stands have experienced around 4” increases in annual water yield. Increased water yield is greatest when harvest occurs close to riparian areas. In areas where the fir under story is removed from Ponderosa Pine sites, water yields have increased 6”. Clearing of Ponderosa Pine forest overstory on one sixth of a watershed and thinning the rest of the watershed increased water yield by about 2.5” annually. Water yield increases in Pinyon-Juniper woodlands area vary depending on the subsurface flow regimes. Some areas have measured less half an inch annual increases. (Ffolliott, 1977) (Rothacher 1970) Based on these figures, Little Pine Creek would experience an increase in water yield of approximately 0.9 cfs (spread across the entire year) or 630 acre-feet if a fire intensely burned the heavily fueled upper portions of the watershed. This is an increase of approximately 28%. Increased annual water yield in the other watersheds in the project area can be expected to increase as well.

EFFECTS ON STREAM CHANNEL GEOMETRY

Large watershed events, such as a wildfire, can reset the channel geometry of a stream. Fire's effects on stream channel geometry can be direct or indirect, and vary with fire local and intensity. Fire in a watershed can increase streamflow and sediment movement into and through downstream aquatic ecosystems. If fire burns directly in the stream channel, it can consume part or all of the vegetation and large wood in the stream channel. In this scenario, the stream channel would loose its structure. As a result, the sediment previously trapped behind the woody debris and vegetation would become available to be washed downstream. This increased sediment load could combined with increased peak flows to create high erosive stream energies. Erosive flows would result in large sediment inputs from the channel itself. In Little Pine Creek, the moderately sinuous reaches that are still recovering from mining disturbances would transform in to more entrenched channels. This entrenchment could be moderated by episodic inputs of large organic debris from other parts of the watershed.

Episodic inputs of large organic debris to the floodplain occur due to events such as epidemics of insects or fires. Fires burn trees lining banks and slopes of streams. The roots of the dead trees loose the majority of their strength within 7 years. (Pritchard, 1998) Eventually, wind blows these trees onto the floodplain and into the stream channel. Insect infestation is another large episodic event that could result in streamside trees dying and falling into the stream channels. An insect infestation is currently in progress across much of the mountain (see forestry discussion).

Increasing organic debris in Little Pine Creek would increase aquatic habitat diversity by forming pools and protected backwater areas, providing nutrients and substrate for biological activity, dissipating energy of flowing water and trapping sediment. Large woody debris hydraulics would change the sediment routing and channel morphology of Little Pine Creek and its forest ecosystem. The effectiveness of the hydraulic resistance provided by the large woody debris would vary with debris size and spacing. Large affixed logs extending partially across the channel would deflect the current laterally, causing it to widen the streambed. Sediment stored by debris would also add to hydraulic complexity. The large wood would anchor and stabilize the position of pools in the direction of streamflow and increase depth variability. Fallen trees on gravel bars would provide sites where some stream-transported species of hardwoods and shrubs could re-root and grow. Also, large fallen trees would help the forest stand to reach a stage of structural development that would allows it to withstand floods better. (Brooks, 1997)

Increased streamflow after a severe fire may scour out stream channels and create a new arrangement of gravels and fines that diversify fish habitat. High intensity fires in forested areas may create large woody debris, which helps stabilize soil on the slopes. Some of these burned tree boles and other debris can reach streams, where they create habitat diversity that improves rearing potential of fish (Everest and Harr 1982). Erosion may contribute debris (via debris flows) to streams and account for water transporting pieces of debris.

The sediment contributed from the burned watershed (see Watershed Erosion Section above) would be detrimental for the aquatic ecosystems that would be expected to occur in Little Canyon Mountain Watersheds. Despite the detrimental effects of sediment on aquatic ecosystems, severe fires can result in diversification of the stream channel geometry.

To summarize, a stable stream channel reflects a dynamic equilibrium between incoming and outgoing sediment and streamflow (Rosgen, 1998). Increased erosion after fires can alter this equilibrium by transporting additional sediment into channels (aggregation). However, increased peakfows that result from fires can produce channel erosion (degradation). In Little Pine Creek it is likely that the meander reaches will become aggrading reaches, while the entrenched reaches will become further entrenched by the degradation. This is generally true for the rest of the project area stream channels. Unfortunately, the large wood available to contribute to debris jams may be reduced by its probable removal during historic mining and settlement.

EFFECTS ON STREAM WATER QUALITY

Undisturbed forest, shrub, and range ecosystems usually have tight cycles for major cations and anions. This results in low concentrations in streams. Disturbances such as fires and insect outbreaks interrupt or temporarily terminate uptake by vegetation, may effect mineralization, microbial activity, nitrification, and decomposition. These processes result in the increased concentration of inorganic ions in soil that can be leached to streams. (Debano, 1998) After fires, nitrates are highly mobile. Most studies of forest disturbances show increases in nitrates (Robichaud, 2000). Studies between unburned, only burned, and burned and fertilized watersheds in Eastern Washington found that total phosphorus increased by 1.5 to 3 times in the burned watersheds compared to unburned watersheds. Nitrates were also notably higher in the burned watersheds compared to the unburned watersheds. In the second year, nitrates in the burned watersheds were twice as high as the unburned water sheds. (Tiedemann, 1978)

In Oregon, fire was frequent historically. (Fitagerald, 2002) Under the no-action alternative, a fire on Little Canyon Mountain is likely to severe. A severe wildfire that consumes much of the surface organic layer will cause a temporary increase in available nitrogen and other nutrients of greater magnitude than a low severity fire.

Nutrient losses from burned watersheds result primarily from streamflow export. Dissolved chemical concentrations are commonly measured to determine these losses.

However, sediment transport is another important source of nutrient losses. (Fisher, 1978). This is one way in which water quality effects on the drier West side of Little Canyon mountain will be somewhat different from the rest of the forested project area. The slopes on the West side of Little Canyon Mountain are more sparsely vegetated. These areas can contribute large amounts of particles from drainage nets that may consist of dry headwater rills or dry washes. These contribute suspended sediment materials to stream flows. Rill and gully erosion deposits nutrient laden sediments downslope and into streams; resulting in nitrogen losses. It was estimated on the Entiat Wildfire of central Washionton, that erosion and debris flows resulted in losses of 809 lb/ac (Grier, 1975). Nutrients such as nitrogen, sulfur potassium and phosphorus are sensitive to volatization and may be lost from a watershed during severe fire. (Fitzgerald, 2002)

Stand-replacement wildfires remove streamside vegetation that shades streams from solar radiation and increases air temperature. The loss of forest canopy and riparian vegetation from wildfire has been shown to increase stream temperatures. Mid-summer temperature increases in Eastern Washington burned watersheds measured up to 9.9 F. Some researchers have suggested that increased streamflows due to the removal of transpiring vegetation might help moderate stream temperature increases. (Helvey, 1980) Large wood contributed to streams from fires may shade the stream a little in the short term, and become integrated into the channel to provide channel complexity in the long term.

Burning may affect streams and fish habitat by causing erosion and sedimentation, releasing nutrients, increasing water temperature by removing streamside shade and by direct heating during burning (Everest and Harr 1982). Amaranthus studied stream shading and maximum water temperatures following an intense wildfire in headwater streams in southwestern Oregon in 1989. This study found that stream temperature increased from 58.3 F above intense wildfire to 70 F just over a mile downstream. This was the average temperature increase of three streams in the study area.

SUBSURFACE MOVEMENT

The No Action Alternative is not expected to impact the aquifer in Section 6. Sub surface movement of water through the soil

ROADS

In addition to theses direct effects of a catastrophic fire, fire suppression activities can negatively impact watershed health.   Little Canyon Mountain's close proximity to Canyon City and several private homes may exacerbate feelings of desperation and result in excessive land disturbance during fire suppression activities. Cat trails increase erosion rates and expand the drainage network.

Studies suggest that the effect of roads on a basin streamflow is generally smaller than the effect of forest cutting. This is primarily due to the fact that the area occupied by roads is much less than that occupied by harvest operations. On the other hand, hydrologic recovery after road building takes much longer than after forest harvest because roads modify physical hydrologic pathways that affect the routing of flow through the watershed. The magnitude of the effects of roads depends on their geomorphic setting, drainage design, and the proportion of the watershed that they cover (Hermann, 2000).

Environmental Affects of Management Alternatives

COMMON TO ALL MANAGEMENT ALTERNATIVES

Most management alternatives are not expected to result in excessive mass movements or erosion because the soils of Little Canyon Mountain are fairly rocky and stable (see discussion in Soils and Minerals sections). Therefore, the hydrologic analysis has focused on changes in the annual hydrograph, sedimentation from roads, and water quality.

Broadcast burning and piling can degrade water quality and fish habitat in small streams, but seldom do so because of the low spatial and temporal intensity of the activities. The highest risk of habitat damage from silviculutral activities occurs in areas with erosive soils and high annual precipitation (Everest and Harr 1982). Little Canyon Mountain soils are not highly erosive and annual precipitation is relatively low.

Mitigating measures have been prescribed for harvest activities under all alternatives. The majority of the project area would be logged by helicopter. The use of helicopters minimizes ground disturbance in the watershed. Large landing construction would disrupt some hillslope processes. However, the landing(s) is at a high position the watershed and disruption of subsurface flow would be negligible. The main concerns associated with lands are their appropriate rehabilitation and the control of weeds that could alter the watershed cover. Proper rehabilitation will mitigate these concerns.

Buffers around streams and springs are part of a conservation strategy. They will protect headwater riparian zones so that when debris slides and flow occur (rarein these stable soils) they contain large wood and boulders necessary for creating habitat farther downstream. Riparian zones along larger channels need protection to limit banks erosion, ensure an adequate and continuous supply of large wood to channels, and provide shade and microclimate protection. Buffers also ensure that sufficient trees and shrubs are available to stabilize slopes with their root strength. This protects against catastrophic debris flows. These buffers also maintain source trees for future large woody debris and large wood in riparian areas. Riparian widths greater than or equal to 100 feet retain sufficient liter inputs to maintain biotic community structures in the stream. Buffers also provide canopy cover for shading of the streams. (FEMA, 1993) In turn, this ensures the protection and enhancement of stream temperature. This is particularly important for the 303d streams. A functional continuous canopy currently exists over Little Pine Creek. Buffers also act to filter sediment and runoff from harvested areas.

Buffers were extended beyond the lengths prescribed by PACFISH in some intermittent drainages and around springs. Buffers selected for this project reflect the anticipated increase in annual water yield and the associated increased length of channel flow. The necessity of these buffers is expected to decrease after 3 to 5 years because the grass and canopy of the remaining trees will require some time to expand into the openings created by the harvest activities. In other areas, buffers were extended to protect points of diversion for domestic use. All point of diversions for domestic or irrigation water rights will have at least a 150ft buffer from ground disturbing activities. Oregon Department of Environmental Quality does not currently have a standard for protection. Therefore, PACFISH buffers were applied.

COMMON TO ALTERNATIVES C through F

Partial cuts, which remove 10% to 40% of the basal area, do not experience the same sublimation loss of precipitation that clear cuts or wild fires experience. In these cases, the snow is no longer intercepted and vaporized. Instead, it accumulates under the remaining canopy as additional snowpack. This may translate to an increase in water available for melt and streamflow. (Troendle 1984)

A thorough literature search was conducted in an attempt to correlate canopy cover percent to basal area for habitat types, and with one exception, none was found. Dealy (1985) did an estimate of tree basal area as an index of thermal cover for elk. While the information helpful, the regression shown in this paper applied to unthinned stands. An on-site examination of basal area and correlated canopy closure (based on satellite imagery) for treated stands in the Ochoco National Forest was done to help in making canopy closure estimates. For analytical purposes in determining effects, the amount of canopy cover was estimated and correlated to basal area as follows:

Basal Area (ft2 per acre)	Estimated % Canopy Closure	Structural Definition
30-60	10-39	Open
60-120	40-69	Moderate
120+	70-100	Closed

These figures are only valuable in comparing and contrasting alternatives. They are not intended to be represent a precise quantitative analysis in the changes to stream flow. A precise quantification of stream flow changes is not possible because there is no field data collection of information on cover available.

As mentioned above, minimum net solar radiation occurs in canopy range of 15% to 30%. The critical range of canopy cover where net radiation is at a minimum is important for analysis of forest management alternatives because it results in the least energy available to ripen the snow pack. For Little Canyon Mountain, it has been estimated that this canopy cover exists where the basal area ranges from 30 to 60. The areas thinned to this basal area can be expected to experience the slowest rates of snowmelt. All the alternative increase the percent of the project area that falls into the cover range from 15% to 30% and decrease the percent of the project area which falls into greater cover ranges. Therefore, all the alternatives will result in some degree of lengthening of the time required for the snow pack to melt.

Annual water yield increases due to vegetation manipulation vary depending on the type of vegetation. Mixed Conifer Forests (Ponderosa and Douglas Fir) stands have experienced around 4” increases in annual water yield. Increased water yield is greatest when harvest occurs close to riparian areas. In areas where the fir understory is removed from Ponderosa Pine sites, water yields have increased 6”. Clearing of Ponderosa Pine forest overstory on one sixth of a watershed and thinning the rest of the watershed increased water yield by about 2.5” annually. Water yield increases in Pinyon-Juniper woodlands area vary depending on the subsurface flow regimes. Some areas have measured less half an inch annual increases. (Ffolliott, 1977) (Rothacher 1970) Based on these figures, Little Pine Creek would experience an increase in water yield of approximately a sixth of a cfs (spread across the entire year) or 120 acre-feet for all of the alternatives. This approximately a 5% increase is within the range observed in catchment studies (Bosch, 1982) (Whitehead 1993). Overall, water yield will increase, but this increase will be distributed across the annual hydrograph, rather than concentrated during peak flows. This distribution is due to the increase in the portion of the watershed that will be at minimum solar input for melting snow, and lack of sublimation.

Indirect Effects on Resource

The risk of catastrophic wildfire is not reduced by this alternative. Thinning would occur in the lower elevations of the project area in the Long Gulch, Rich Gulch and Quartz Gulch drainages that are already disturbed by roads and historic mining activity. Therefore, the majority of Little Canyon Mountain watersheds would still be susceptible to an active crown fire. Only a small portion of the project area would be thinned to reduce the risks of wildfire. Therefore the effects of this alternative are only slightly spatially modified from the No Action Alternative.

In addition, this alternative has the most frequent re-entry interval (5-10 years). Frequent re-entry with mechanized equipment results in more frequently trafficked roads and more frequent soil disturbance in the watershed.

1 year

Sediment yields are likely to increase. Robichaud and Brown (1999) studied erosion rates after a wildfire in Eastern Oregon Ponderosa Pine. They found that first-year erosion rates after a wildfire ranged from 0.5 to 1.1 tons per acre. These rates decreased by an order of magnitude by the second year.

5 years

It is likely that sediment yields from the watersheds would still be higher than pre-fire levels. Low severity burned area would have re-vegetated. After three years the sediment yields would have returned to normal levels (Debano, 1996).

10 years

A study follow a wildfire in Ponderosa pine, reported sediment yields from a moderately to high severely burned watershed did not return to normal until 7 and 14 years, respectively (Debano, 1996). These values represent the amount of time required for vegetation establishment to return erosion to more natural levels.

HISTORIC

Direct Effects on Resource

As mentioned above, minimum net solar radiation occurs in canopy range of 15% to 30%. This alternative increases the percent of the project area that falls into this range by a quarter. This will result in a lengthening of the time required for the snow pack to melt. This alternative creates very large openings, similar to those created by a more natural wildfire regime. In these openings, the snowpack experiences maximum losses to sublimation. (Troendle 1984) Although this loss can result in decreased runoff and streamflow, the number of openings in this alternative is not expected to have a measurable impact on streamflow.

Harris and Hubbard found forest cover to be an important factor in calculating regional flood-frequency equations for this Northeast region. Using these regional equations, bi-annual peak flows were predicted to increase %2. The hundred-year flood would increase %4. The hundred year flood calculated value has a standard error of plus %101 or minus %50, but it is useful for comparison with the management alternatives. (see Appendix D)

The targeting of juniper for removal from the Western and Northern portions of the project area will improve infiltration, decrease erosion, increase water yield, and increase interception. Sites where juniper have encroached foster biomass concentrations at the tree with increasing amounts of bare ground in the interspaces become direr from decreased infiltration of precipitation into the soil profile and increased surface flows, which quickly carry water off-site. Sites also become drier with increasing juniper dominance because of interception and evaporation, gully erosion, and a lowering of the capillary fringe associated with influent ground water systems and dessert streams. This ground water effect may only be happening on the Northern portion of the project area where the alluvial soils could facilitate such a change. (Buckhouse 2002) In juniper-dominated sites, the juniper decreases the amount of water available to the understory of bunch grasses by intercepting precipitation and then funneling the water through stemflow down the trunk. This stemflow moves water directly to the base of the tree for the juniper roots to use.

Removing the juniper will return the site to a grassland ecosystem if the site has not crossed the threshold into juniper woodland. If enough grass plants remain under the juniper canopy, a juniper cut would release nutrients and increase the available water so that the site may revert to grassland. If that is not the case, removing the juniper will simply result in runoff and erosion rates that are greater than the already elevated rates until young juniper re-establish on the site. Successfully converting the site to grassland is anticipated. This will result in an approximate decrease in sediment production by a factor of almost 4. At one site, the removal of juniper trees resulted in a lengthening of the growing season for herbaceous understory of 6 weeks compared to adjacent uncut woodlands.(Buckhouse 1999) In addition, junipers are capable of transpiring 30 gallons or more per day. This water would be available for storage in the soil, infiltration and runoff. Successful conversion would increase infiltration, decrease erosion, increase water yield, and increase interception.

Indirect Effects on Resource

1 year

Removing large trees from the base of transpiring plants in the riparian areas will increase annual water yield until other riparian woody species, such as red alder, vegetate the open spaces. The removal of fir will have the most dramatic effect – transferring up to 6" of precipitation from evapotranspiration to stream flow. (Ffolliott, 1977) This increase over 10 acres does not appreciable affect annual water yield.The riparian treatment will also allow more energy to reach the stream channel in the form of sunlight. In this highly shaded stream, increased sunlight will increase the biotic community of algae, macroinvertebrates, and biotic life in general.

Some studies have shown an increase in springs and wet meadows as a result of targeting Juniper trees for removal (McCarthy III, 1999). The majority of juniper occurs on the western portion of Little Canyon Mountain. The igneous geologic formations on this side of the mountain are not conducive to creating perched water tables. Most of the water flows down into fractures in the rocks. The spring in Whiskey Gulch appears to originate in fractured bedrock. This would suggest that the springs on this steep mountainside would not experience any measurable increases in yield. Therefore, the existing points of diversions should not be affected. Removal of the juniper will make more water available for herbaceous species, effectively changing the watershed cover and characteristic response of the watershed to precipitation.

Several well logs from section 6 suggest the presence of a confined aquifer in the alluvial toe slopes of Little Canyon Mountain. Alternating layers of clay and gravel at the slope of the igneous rocks of Little Canyon mountain create the potential for shallow perched aquifers which fluctuate seasonally. Juniper removal may have some slight affect on the flow regimes in these soils. However, it would be difficult for juniper tap roots to reach the deep water table indicated by the well logs.

5 years

On the harvested portions of the watershed, increases in herbaceous species will be fully expressed. Bunchgrasses and forbs have the potential to be more widespread than before the juniper was targeted. A large portion of precipitation previously intercepted by the juniper and funneled down its trunk to its roots will now be intercepted by the grass and infiltrated.

The riparian treatments in the RHCAs will be revegetating with riparian vegetation. A study in the Oregon Coast rang found that stream temperature increases due to removal of riparian vegetation returned to pre-treatment levels in 5 years. (Fitzgerald, 2002) Woody riparian species, such as Alder and Birch, will have begun to express themselves in the opening created in the RHCAs.   Several seasonal cycles of flooding will have occurred to anchor and refine the placement of large woody debris in the stream channel. The large wood will deflects flood flows and sediments will have been deposited onto the floodplain.

10 years

Small juniper may be re-establishing on the watershed, but their affect on watershed cover will be minimal due to their small stature.

A low intensity fire may still occur under this alternative. This would result in a temporary increase in available nitrogen. (Fitagerald, 2002)

This alternative has a relatively infrequent re-entry interval of 10-30 years. This will result in more complete recovery between vegetation treatments. In addition, there will be less soil disturbance and road trafficking across time.

UNIFORM

Direct Effects on Resource

As mentioned above, minimum net solar radiation occurs in canopy range of 15% to 30%. This alternative increases the percent of the project area that falls into this range by more than half. This will result in a lengthening of the time required for the snow pack to melt.

Harris and Hubbard found forest cover to be an important factor in calculating regional flood-frequency equations for this Northeast region. Using these regional equations, bi-annual peak flows were predicted to increase %6. The hundred-year flood would increase %9. The hundred-year flood calculated value has a standard error of plus %101 or minus %50, but it is useful for comparison with the management alternatives. (see Appendix D)

The installation of a 1 mile fence to restrict cows from utilizing the riparian vegetation along Little Pine Creek will ensure that the provisions for riparian recovery outlined in this plan will be effective. In addition, riparian recovery that has already occurred in the meandering sections of Little Pine Creek will continue (increased riparian vegetation, decreased with to depth ratio, and decreased fines).

1 year,

ROADS

Proposed Treatment	Feet	Miles
Decommission	27423	5.2
No Treatment	125914	23.8
Rock & Erosion-Proof	9611	1.8
Total	162948	30.9

Treatment in PACFISH buff	Feet	Miles
Decommission	12878	2.4
No Treatment	10632	2.0
Rock & Erosion-Proof	1915	0.4

The effects of forest roads were outlined in “Existing Environment” and “No Action Alternative.” Decommissioning these 5.2 miles of roads will eliminate 20 stream channel crossings and reduce sedimentation from roads by X tons per year (based on WEPP modeling). The main road is currently in very bad condition in many areas, due to inadequate drainage and rutting due to high traffic levels. Rocking and Erosion-Proofing the main road will reduce sedimentation from it by X tons per year (based on WEPP modeling).

While re-routing ½ a mile of road will disturb approximately 1 ½ acres, 5 acres of currently roaded areas will be revegetated. Furthermore, the rerouted road will fix an erosion problem at an intersection of a road and a historic ditch. This site is currently eroding a gully out of a road that runs straight up the hillside. A switchback would be constructed at this site and drainage dips and ditches would decrease the erosive energy of the water by diverting it away from the road towards the vegetated hillslope before it gathers momentum.

5 years,

Some revegetation of the decommissioned roads will have occurred. However, roads disrupt hill slope processes, and it takes many years for the subsurface flow regimes to reconnect across the disturbed areas. On the other hand, effects from harvest activities would have rapidly decreased, even stabilized. This is due to the expansion of herbaceous and shrub species into the open areas created by thinning. The remaining tree canopy would also begin to expand and intercept more moisture.

The long term reduction of fines to Little Pine Creek will reduce the amount of fines that fill in pools and create embedded riffles. These effects will begin to decrease as flood flows flush fine sediments out of the watershed.

10 years

A low intensity fire may still occur under this alternative in the future. This would result in a temporary increase in available nitrogen. (Fitagerald, 2002) This alternative has the least frequent re-entry interval of 30 years. This will result in more complete recovery between vegetation treatments. In addition, there will be less soil disturbance and road trafficking across time.

ROAD DECOMMISSIONING RECCOMENDATIONS

Simple road closures with blocked entrances may not be effective in this highly trafficked region in close proximity to Canyon City and John Day. Under these trafficked conditions, the rill erodibility would be relatively high. Wheel traffic tends to fore gravel into the rut bed, with more easily detached sediment extruding up and around the gravel. In the absence of traffic, it is believed that the rut area would soon armor or consolidate, resulting in a relatively low, rangeland level of erodibility. (Ellion 1994) Therefore, the most effective way to reduce sediments from the identified roads is to 1) close all main access roads to the area, and 2) recontour the main access roads and those which pose a continuing erosion hazard.

Full road fill pullback, also known, as “re-contouring” is the deconstruction of the road sub grade to restore the original hillslope profile and contours. Full road fill pullback typically involves decompaction and removal of the road surface to establish safe working areas and increase the downslope reach of the excavator. Where very long and deep road fills area present, benching or ramping may be needed to adequately retrieve and place all the road fill present. In cases where all of the retrieved material cannot be placed on a stable bench, end hauling may be needed. Woody debris is randomly scattered on the surface of the pullback material, promoting re-vegetation and inhibiting deer movement to reduce browse on seedlings.

Decompaction may be necessary for full road fill pullback especially in areas of heavy seepage. Decompaction is the breaking up of road fill materials (ballast and sub grade) to a depth equal to or greater than, the depth of the ditch. The decompacted surface is outsloped, to provide better downslope reach and promote water flow across the road under the pullback material. Decompaction of the road fill can also define the width of the natural bench so that a safe working limit for the excavator can be established (Hillslope Restoration in BC November 2001). All surfaces would be hand seeded and possibly planted with seedlings to encourage re-vegetation.

In the event that the prescriptions above are included in the record of decision, the site-specific road crossings (20) should be repaired and modified to reduce sediment into the stream channels until the roads are closed or permanently repaired. Installation of W-weirs, and bendway weirs, and other road crossing improvements would decrease sediment delivered to the streams. (Johnson, Peggy A. 2002)

GRADED

A mixture of forest and open areas on a watershed may promote snowmelt at different times and thus reduce streamflow peaks (Anderson, 1976). Snow on southerly aspects may disappear before much snow of the melts on northerly aspects.

Harris and Hubbard found forest cover to be an important factor in calculating regional flood-frequency equations for this Northeast region. Using these regional equations, bi-annual peak flows were predicted to increase %2. The hundred-year flood would increase %4. The hundred year flood calculated value has a standard error of plus %101 or minus %50, but it is useful for comparison with the management alternatives. (see Appendix D)

The main road is currently in very bad condition in many areas, due to inadequate drainage and rutting due to high traffic levels. Rocking and Erosion-Proofing the main road will reduce sedimentation from it by X tons per year (based on WEPP modeling).

Indirect Effects on Resource

1 year

Extensive research has demonstrated that improved designing, building, and maintaining of roads can reduce road-related surface erosion at the scale of individual road segments. Road improvements to the main road will include rocking, re-shaping, adding drain dips, and other improvements. (Herman, 2000) These improvements will result in a cumulative decrease of X sediment yielded from this road compared to the current condition. (WEPP model)

5 years

The long term reduction of fines to Little Pine Creek will reduce the amount of fines that fill in pools and create embedded riffles. These effects will begin to decrease as flood flows flush fine sediments out of the watershed.

10 years

A low intensity fire may still occur under this alternative. This would result in a temporary increase in available nitrogen. (Fitagerald, 2002) This alternative has a relatively infrequent re-entry interval of 20-30 years. This will result in more complete recovery between vegetation treatments. In addition, there will be less soil disturbance and road trafficking across time.

STRATIFIED

A mixture of forest and open areas on a watershed may promote snowmelt at different times and thus reduce streamflow peaks (Anderson, 1976). Snow on southerly aspects may disappear before much snow of the melts on northerly aspects.

Harris and Hubbard found forest cover to be an important factor in calculating regional flood-frequency equations for this Northeast region. Using these regional equations, bi-annual peak flows were predicted to increase %2. The hundred-year flood would increase %4. The hundred year flood calculated value has a standard error of plus %101 or minus %50, but they are useful for comparison with the management alternatives. (see Appendix D)

EFFECTS ON STREAM FLOW

More snow accumulates in sparsely stocked forest stands and in small clearings in forest stands than in dense conifer stands. These greater accumulations can contribute to increased runoff, particularly when such increases occur in areas that already have wetter soils. Selective thinning can increase snow accumulation in an estimated range between 6 and 15 %, while heavy thinning and commercial clearcuts can increase snow accumulation between an estimated 15 and 29%. (Anderson et al. 1976) If air temperature is near 0 C when snow falls or if snow is present on the forest canopy when rain occurs, higher outputs of water occur from forested areas than from cleared areas. The snow-covered canopy offers a greater surface area exposed to convection-condensation processes than the snowpack surface in a cleared area does; more rapid melt occurs from the snow on the canopy. If no snow is present on the forest canopy when rain occurs and rainfall rates exceed 5 mm/hr, clearcut areas yield more water than forested areas once the snowpack is ripe (warm). (Barris and Harr 1987) Wind accentuates these differences. Maintaining a diversity of cover conditions on a watershed can moderate the effects in either scenario.

EFFECTS ON STREAM FLOW

The energy available to either ripen a snowpack or to melt snow can be summed up in an energy budge. The energy available for snowmelt is the sum of incoming shortwave solar radiation, the radiation lost due to albedo of the snow pack, incoming longwave radiation, outgoing longwave radiation, convective transfer of sensible heat, conduction at the snow-gound interface, and the flow of latent heat from rain or fog. There is a trade off between shortwave and longwave radiation at a snow pack surface as the forest cover changes. As forest cover increases, the solar radiation at the snow pack surface is reduced greatly; the longwave radiation loss from the snow pack is reduced and the longwave gain component from the canopy increases. Between 15 and 30% canopy cover, net radiation at the snowpack surface is at a minimum; net radiation is highest at 0% cover, but it is also relatively high at dense forest canopy conditions because of the much higher net long wave component. (Brooks and others, 1997) These relationships impact

Clear cutting Douglas Fir in Western Oregon has estimated annual water yield increases of 18 inches. (Rothacher, 1970) Estimates for areas east of the cascades place potential yield increases closer to .5 and 1 inches for Ponderosa pine and Douglas Fir, respectively. That is about a 13 to 15% increase in mean annual stream flow. (Anderson, 1976).

Patch cutting with roads of 30% of a watershed in the Douglas-fir type in Western Oregon increased water yield about 8.5 inches per year over a 5 year period. (Rothacher, 1970) If patch cutting in Eastern Oregon results in a proportional smaller increase in water yield, Ponderosa pine and Douglas Fir will experience a 7 to 8 5% increase in peak flows from Patch cutting.

Direct Effects on Resource 10 years

Opening the forest in the West has relatively long-lived effects on yields of snow and water; increases probably last 20 years or more. Savings in interception losses may persist to the culmination of the leaf surface on re-growth, about 35 years (Anderson, 1976). This alternative has a relatively infrequent re-entry interval of 10-30 years. This will result in more complete recovery between vegetation treatments. In addition, there will be less soil disturbance and road trafficking across time.

Indirect Effects on Resource (1 year, 5 years, 10 years)

A low intensity fire may still occur under this alternative. This would result in a temporary increase in available nitrogen. (Fitagerald, 2002)

APPENDIX A

Little Pine Creek Reference Reach Summary

Reference Reach	
Stream:	Little Pine Creek
Watershed:	Little Pine Creek
Location:	Little Canyon Mountain
Latitude:	42.3921
Longitude:	119.995
County:	Grant
Date:	September 26, 2002
Observers:	Anna Smith, Ed Horn, Kate Peterson, Ryan Franklin, John Morris, Colleen Wyllie
Channel Type:	B4
Notes:	surveyed for Little Canyon Mountain Fuels Reduction Project

Dimension

		typical	min	max
Size:	x-area bankfull	11.0	5.3	11.8
	width bankfull	16.9	6.1	17.6
	mean depth	0.7	0.7	0.9
Ratios:	Width/Depth Ratio	26.0	7.0	26.3
	Entrenchment Ratio	2.2	1.5	2.5
	Riffle Max Depth Ratio	2.5	1.7	2.5
	Bank Height Ratio	2.0		

Hydraulics:	riffle	pool	run
discharge rate, Q (cfs)	30.0	30.0	30.0
velocity (ft/sec)	2.7	---	---
shear stress @ max depth (lbs/ft sq)	2.85	---	---
shear stress (lbs/ft sq)	1.07	---	---
shear velocity (ft/sec)	0.74	---	---
unit stream power (lbs/ft/sec)	3.165	3.165	3.16
relative roughness	1.4	---	---
friction factor u/u*	3.7	---	---
threshold grain size @ max depth (mm)	559.8	---	---
threshold grain size (mm)	83	---	---

Channel Materials

	total	riffle	pool	run	glide	bar sample
D16	1.325	5.636	#N/A	0.0	0.0	---
D35	8.78	24.43	3.93	0	0	---
D50	31.4	51.8	10.7	0	0	---
D84	142.2	150	131	0	0	---
D95	227.1	207	292	0	0	---
Largest Bar						0
% Silt/Clay	14%	10%	17%	---	---	---
% Sand	5%	1%	9%	---	---	---
% Gravel	43%	44%	43%	---	---	---
% Cobble	34%	42%	26%	---	---	---
% Boulder	4%	2%	6%	---	---	---
% Bedrock	0%	0%	0%	---	---	

APPENDIX B

Overholt Creek Reference Reach Summary

Reference Reach	Hints
Stream:	Overholt Creek
Watershed:	Indian Creek
Location:	Upstream from John Day Oregon
Latitude:	44.356
Longitude:	118.7178
County:	Grant
Date:	September 6, 2002
Observers:	Anna Smith, Colleen Wyllie, John Morris
Channel Type:	B4
Notes:	This was chosen as reference reach for Little Pine Creek. Overholt Creek flows out of the Strawberry Mountain Wilderness. The two creeks are similar in landscape setting and recently experienced a wildfire in their upper watersheds.

Dimension

		typical	min	max
Size:	x-area bankfull	7.6	6.0	9.0
	width bankfull	13.0	6.7	16.8
	mean depth	0.6	0.5	1.0
Ratios:	Width/Depth Ratio	22.2	---	---
	Entrenchment Ratio	2.7	---	---
	Riffle Max Depth Ratio	2.1	1.7	4.8
	Bank Height Ratio	2.5		

Hydraulics:		riffle	pool	run
	discharge rate, Q (cfs)	27.0	27.0	27.0
	velocity (ft/sec)	3.6	---	---
	shear stress @ max depth (lbs/ft sq)	2.10	---	---
	shear stress (lbs/ft sq)	1.05	---	---
	shear velocity (ft/sec)	0.74	---	---
	unit stream power (lbs/ft/sec)	3.629	3.629	3.63
	relative roughness	2.3	---	---
	friction factor u/u*	4.8	---	---
	threshold grain size @ max depth (mm)	307.1	---	---
	threshold grain size (mm)	79	---	---

Channel Materials

	total	riffle	pool	run	glide	bar sample
D16	2.264	3.105	#N/A	0.0	0.0	---
D35	15.31	16.83	7.55	0	0	---
D50	24.5	26.6	18.1	0	0	---
D84	75.9	76	67	0	0	---
D95	124.6	118	154	0	0	---
Largest Bar						0
% Silt/Clay	15%	13%	23%	---	---	---
% Sand	0%	0%	1%	---	---	---
% Gravel	63%	64%	59%	---	---	---
% Cobble	22%	23%	16%	---	---	---
% Boulder	0%	0%	1%	---	---	---
% Bedrock	0%	0%	0%	---	---	

APPENDIX C

Project Area Water Rights

Application	Permit Number	Permit	Certificate	Priority Date	Rate (cfs)	Source	POD in project Area?	Use
G 2780	2594	G 2594	39637	1964	0.145	Canyon Creek	No	Municipal
S 4546	2658	S 2658	37365	1915	0.55	Rich Gulch (Gold Gulch)	Yes	Irrigation
G -10244	9319	G 9319	67796	1981	2.23	John Day River Well	No	Municipal
S 15266	11185	S 11185	11780	1934	1	Little Pine Creek	Yes	Mining
S 15535	11416	S 11416	11632	1934	1	Byram Gulch	No	Municipal
S 23931	18845	S 18845	21471	1949	0.25	Byram Gulch	No	Municipal
S 24290	19120	S 19120	21352	1949	0.01	Canyon Creek	No	Irrigation and Domestic
D 0	24978	D 24978	24978	1905	0.093	Whiskey Gulch	Yes	Municipal
D 0	25774	D 25774	25774	1892	1.4	Little Pine Creek Trib	No	Irrigation and Domestic
T 5394	25775	S 25775	51976	1888	0.5	Little Pine Creek	Yes	Irrigation
S 34721	27262	S 27262	30276	1961	0.01	Canyon Creek	Yes	Domestic
S 37680	28083	S 28083	39642	1962	0.42	Little Pine Creek	Yes	Irrigation
S 38959	29034	S 29034	45113	1963	0.34	Little Pine Creek	Yes	Irrigation
	28418	S 28418	61057	1962	0.38	Little Pine Creek	Yes	Irrigation
S 49358	37001	S 37001	44938	1972	0.1	Little Pine Creek	Yes	Irrigation
S 50207	37897	S 37897		1973	1	Little Pine Creek	Yes	Mining
S 51554	38896	S 38896		1973	0.07	Whiskey Gulch	Yes	Irrigation and Domestic
S 51794	39137	S 39137		1974	0.02	Rich Gulch Springs	Yes	Irrigation and Domestic
S 54950	41242	S 41242		1976	0.75	Little Pine Creek	Yes	Mining
S 61359	45910	S 45910		1981	1	Little Pine Creek	Yes	Mining
S 64136	47107	S 47107		1982	0.33	Canyon Creek	Yes	Mining
S 65817	48021	S 48021	65733	1983	0.02	Rich Gulch	Yes	Irrigation
S 68731	49705	S 49705	11632	1986	0.01	Little Pine Creek Trib	Yes	Domestic
R 7682	101544	R 101544	70333	1993	.095 acre-ft	Little Pine Creek Trib	No	Livestock

APPENDIX D

Little Pine Creek Peak Flow Variation Due to Change in Forest Cover

Region Flood-Frequency Equations, NorthEast Region by Harris and Hubbard 1983					
ASSUMING PROJECT AREA REDUCTIONS IN THE FOREST COVER					
		Current Forest Cover	Burn in Project Area*	Alternative D	Alternative C, E, F
Two year Flood=	$Q_{0.5}$ =	31	35	33	32
Five year Flood=	$Q_{0.25}$ =	56	63	60	57
Ten year Flood=	$Q_{0.1}$ =	74	85	79	76
Twenty-Five Year Flood=	$Q_{0.04}$ =	97	113	105	100
Fifty Year Flood=	$Q_{0.02}$ =	121	141	131	125
One Hundred Year Flood=	$Q_{0.01}$ =	140	165	153	145

% Change in Peak Flows based on project area reductions in the forest cover					
		Current Forest Cover	Burn in Project Area*	Alternative D	Alternative C, E, F
Two year flood=	$Q_{0.5}$ =	31	12%	6%	2%
Five year Flood=	$Q_{0.25}$ =	56	14%	7%	3%
Ten year Flood=	$Q_{0.1}$ =	74	15%	8%	3%
Twenty-Five Year Flood=	$Q_{0.04}$ =	97	16%	8%	3%
Fifty Year Flood=	$Q_{0.02}$ =	121	17%	9%	3%
One Hundred Year Flood=	$Q_{0.01}$ =	140	18%	9%	4%

* Assuming that the forest cover is reduced by 100% in the project area

STANDARD ERROR %			
		Plus	Minus
Two year flood=	$Q_{0.5}$ =	82	45
Five year Flood=	$Q_{0.25}$ =	79	44
Ten year Flood=	$Q_{0.1}$ =	83	45
Twenty-Five Year Flood=	$Q_{0.04}$ =	89	47
Fifty Year Flood=	$Q_{0.02}$ =	90	48
One Hundred Year Flood=	$Q_{0.01}$ =	101	50

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