Oatman Restoration Project

Hydrology and Soils Specialist Report

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And
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Fremont-Winema National Forest

Signature: **Vince Pacific**  Date: 6/21/2013

Signature: **Bill Goodman**  Date: 2/12/2014
Project Objectives
The Fremont-Winema National Forest is proposing the Oatman Restoration Project to address multiple resource needs and return the landscape to a condition reflective of the historical range of variance (HRV) on the Silver Lake Ranger District (RD).

Project Location and Hydrologic Unit Codes (HUCs)
The Oatman Restoration Project area is located on the Fremont-Winema National Forest, in the vicinity of Silver Lake, Oregon, in both the Rock Creek/Buck Creek and Silver Creek Watersheds (Table 1). The subwatersheds in which the project area is located and corresponding Hydrologic Unit Codes (HUCs) are shown in Figure 1. The project area encompasses approximately 36,252 acres of land, of which approximately 26,342 acres are National Forest System (NFS) land. Within the NFS land, approximately 12,712 acres would have timber harvest treatments. The project area is entirely within the Silver Lake RD and almost entirely within Lake County, Oregon (approximately 910 acres within Klamath County).

The legal description includes all and/or portions of the following Townships (T), Ranges (R), and sections (Sec): T27S R12E, Sec. 34-35; T27S R13E, Sec. 8, 17-22, 27-32; T28S R11E, Sec. 24-25, 36; T28S R12E, Sec. 1-2, 11-15, 19-35; T28S R13E, Sec. 18-19; T29S R11E, Sec. 1; T29S R12E, Sec. 2-12, 15-21, 29-32; and T30S R12E, Sec. 5-7.

Table 1. Basins, subbasins, watersheds, and subwatersheds, and corresponding HUCs, in which the Oatman Restoration Project area is located.

<table>
<thead>
<tr>
<th>Basin (HUC 6)</th>
<th>Subbasin (HUC 8)</th>
<th>Watershed (HUC 10)</th>
<th>Subwatershed (HUC 12)</th>
<th>Project Area (Acres)</th>
<th>NFS Land within Project Area (acres)</th>
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</thead>
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<tr>
<td>Oregon Closed Basins (171200)</td>
<td>Summer Lake (17120005)</td>
<td>Rock Creek/Buck Creek (1712000501)</td>
<td>Bear Creek (1712000500105)</td>
<td>24,835</td>
<td>15,082</td>
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<td></td>
<td></td>
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<td>Buck Creek (171200050107)</td>
<td>966</td>
<td>966</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Timothy Creek (171200050106)</td>
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<td>5,354</td>
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<td></td>
<td></td>
<td></td>
<td>Silver Creek (1712000502)</td>
<td>Oatman Flat (171200050202)</td>
<td>4,911</td>
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</tbody>
</table>
Figure 1: Location of the Oatman Restoration Project relative to 6th field (HUC 12) subwatersheds. No perennial streams are located within the project area.
Past Activities
Portions of the project area were logged between the 1970s and 1990s, mostly in response to a beetle infestation that caused mortality in portions of the project area. One salvage sale occurred around 2000 in response to the Antelope Springs Fire.

Fire suppression within the project area began around the turn of the 20th century, with the most recent large fires having occurred in 1925 (reported 941.2 acres, NFS and private), 1986 (reported 22 acres, all NFS), and 1991 (reported 162.2 acres, all private). In large part, fuels reduction efforts within the project area have not occurred within the last 30 years.

Data Collection Methodology
General information on the project area is presented in the Silver Creek Watershed Analysis (USDA Forest Service 1997), in which part of the project area is located, and synthesized in this report. Due to the lack of perennial stream flow, Level II Stream Habitat Surveys, which are an extensive inventory that identify existing stream channel, riparian vegetation, and aquatic ecosystem conditions (USDA Forest Service 2010), have not been completed on any of the streams in the project area. GIS and the National Hydrography Dataset were used to calculate stream distances within the project area. The 2010 Water Quality Report by the Oregon Department of Environmental Quality (ODEQ 2010) was used to determine if a stream was officially listed as having impaired water quality (denoted by placement on the 303(d) list). The Fremont National Forest Soil Resource Inventory (SRI) (Wenzel 1979), as amended by the Fremont National Forest Land and Resource Management Plan (LRMP) (USDA Forest Service 1989), was used to help characterize soil conditions within the project area.

Project Area Current Conditions
Climate
Climate in the project area is characterized in the Silver Creek Watershed Analysis (USDA Forest Service 1997). The project location is in a semiarid area east of the Cascade Mountains. Summers are generally dry and annual precipitation ranges from 13 to 35 inches, the majority of which falls as snow from November to January. Air temperatures range from below freezing during winter months to over 100°F during summer, and freezing temperatures can occur at any time of year.

Streamflow
There are no perennial streams within the project area (Figure 2), and Bear Creek and Timothy Creek are the only streams identified with names in the National Hydrography Dataset. Distances of intermittent (seasonal flow) and ephemeral (short-term precipitation- or snowmelt-induced flow) streams within the project area are shown in Table 2, and acres of wetlands and lakes/ponds are shown in Table 3.
Figure 2: Streams, waterbodies, and wetlands within the Oatman project area. There are no perennial streams within the project area.

Table 2: Miles of intermittent and ephemeral streams across the entire project area as well as on only NFS land.

<table>
<thead>
<tr>
<th>Stream Type</th>
<th>Distance: Entire Project Area (miles)</th>
<th>Distance: NFS Land (miles)</th>
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</thead>
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<tr>
<td>Intermittent</td>
<td>50.4</td>
<td>32.7</td>
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<tr>
<td>Ephemeral</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>51.8</td>
<td>34.1</td>
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</table>
Table 3: Acres of wetlands and lakes/ponds across the entire project area as well as on only NFS land.

<table>
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<th></th>
<th>Entire Project Area (acres)</th>
<th>NFS Land (acres)</th>
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</thead>
<tbody>
<tr>
<td>Lake/Pond</td>
<td>78.6</td>
<td>66.0</td>
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<tr>
<td>Wetland</td>
<td>412.1</td>
<td>238.8</td>
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</table>

Stream drainage density, defined as the length of all streams within a watershed divided by watershed area, is a useful indicator for the potential for runoff generation (Gregory and Walling 1968) and sediment yield (Hadley and Schumm 1961). On a highly permeable landscape, or one with few streams, drainage densities less than 1 mile/mile² are possible, indicating a small potential for runoff. In areas with high runoff potential, drainage densities can be over 10 miles/mile² (Gregory and Walling 1968). The stream drainage density across the entire project area is 0.92 miles/miles², and 0.83 miles/miles² on only NFS land within the project area, both of which indicate a very low potential for runoff generation and stream sediment delivery.

Stream Channel Morphology
No Level II Stream Habitat Surveys have been completed within the project area, and bank stability, pool frequency, amount of large woody debris, and stream width:depth ratios have not been quantified.

Water Quality
Stream temperature and turbidity are not measured in any of the streams within the project area. None of the streams are on the ODEQ 303(d) list of impaired streams. However, as water quality measurements are not collected on any stream within the project area, lack of placement on the 303(d) list does not necessarily indicate that streams do not have impaired water quality.

Vegetation
Vegetation in the area is characterized in the Silver Creek Watershed Analysis (USDA Forest Service 1997). The forested portions of the watershed can be divided into three broad ecoclass groups: lodgepole pine associated communities, ponderosa pine communities, and pine associated communities. Compared to the HRV, fire suppression has changed vegetation structure across the landscape. Historically, ponderosa pine stands were typically open and parklike, however there are presently increased densities of understory ponderosa pine, western juniper, and lodgepole pine.

Fire exclusion has also resulted in encroachment of juniper and ponderosa pine into meadow and riparian areas (USDA Forest Service 1997). It is estimated that the current extent of riparian and meadow areas is approximately 950 acres, while the potential extent is 4,530 acres (see the Range Specialist Report for details on how these numbers were calculated).

Soils
Soils within the project area are characterized in the Fremont National Forest SRI (Wenzel 1979). Soils are derived from basalt, andesite, and tuff parent materials, and pumice soils are common. The project area can be stratified into 24 land types (Figure 3), which are areas with similar soils, bedrock, landforms, and vegetation. The majority of these land types cover less than 5% of the project area (Table 4). Land types 30A, 81, 93A, and 99 are the only ones that compose more than 10% of the project area (Table 4). Soils were also analyzed independently for only those areas that would be logged used ground-based heavy machinery (approximately 12,177 acres) (Figure 4, Table 5). See the Fremont National Forest SRI (Wenzel 1979) for a detailed description of each land type. It should be noted that the SRI is not designed to be utilized for areas less than 40 acres (such as some individual logging units), but does provide a general overview of soil conditions and can be useful in site characterization.
Figure 3: Land types on NFS land within the project area, as characterized in the Fremont National Forest SRI (Wenzel 1979).
Figure 4: Land types on logging units on NFS land within the project area that would use ground-based heavy machinery, as characterized in the Fremont National Forest SRI (Wenzel 1979).
Table 4: Land types on NFS land within the project area, as characterized in the Fremont National Forest SRI (Wenzel 1979). Potential for erosion, compaction, displacement, and sediment yield were defined in the Fremont National Forest LRMP (USDA Forest Service 1989), which amended the SRI to meet management needs.

<table>
<thead>
<tr>
<th>Land Type</th>
<th>Hydro Group</th>
<th>Erosion Potential</th>
<th>Compaction Potential</th>
<th>Displacement Potential</th>
<th>Sediment Yield Potential</th>
<th>Acres</th>
<th>Percent of Area</th>
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<td>Moderate</td>
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Table 5: Land types within harvest units using ground-based heavy machinery on NFS land within the project area (approximately 12,177 acres), as characterized in the Fremont National Forest SRI (Wenzel 1979). Potential for erosion, compaction, displacement, and sediment yield were defined in the Fremont National Forest LRMP (USDA Forest Service 1989), which amended the SRI to meet management needs.

<table>
<thead>
<tr>
<th>Land Type</th>
<th>Hydro Group</th>
<th>Erosion Potential</th>
<th>Compaction Potential</th>
<th>Displacement Potential</th>
<th>Sediment Yield Potential</th>
<th>Acres</th>
<th>Percent of Area</th>
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Potential for Sediment Yield, Erosion, Compaction, and Displacement.
Summaries of potential for erosion, compaction, and displacement, as characterized in the Fremont National Forest LRMP (USDA Forest Service 1989), are shown in Table 6. In general, there is not a high potential for compaction and displacement, particularly within the logging units that would utilize ground-based heavy machinery. The potential for erosion is higher when compared to potential for compaction and displacement, however erosion potential is less than 20% within logging units. In general, there is not a high potential for sediment yield across the project area, particularly when focusing on logging units, in which 96.5% of the units have a low potential for sediment yield (Table 6).
Table 6. Potential for erosion (rill and gully), compaction, and displacement within NFS land across the entire project, as well as within only logging units, as defined in the Fremont National Forest LRMP (USDA Forest Service 1989), which amended the SRI (Wenzel 1979) to meet management needs. Sediment yield potential is defined in the SRI.

<table>
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<th></th>
<th>Percent of Project Area</th>
<th>Percent of Logging Units</th>
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<tr>
<td><strong>Sediment Yield Potential</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n/a</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Low</td>
<td>79.1</td>
<td>96.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.6</td>
<td>0.7</td>
</tr>
<tr>
<td>High</td>
<td>16.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

**Hydrologic Soil Groups**
The soils within the project area were divided into four hydrologic soil groups, which indicate the general infiltration and water movement ability of the soil and bedrock materials (Wenzel 1979). Soils within hydrologic soil group A are deep, well to excessively drained sands and/or gravels that have high water infiltration and transmission rates when thoroughly wetted. Hydrologic soil group B is characterized by soils that are deep to moderately deep, moderately well drained to well drained, have moderately fine to moderately coarse texture, and have moderate water infiltration and transmission rates. In general, soils within groups A and B have a low runoff potential. Hydrologic soil group C consists of (1) soils with a layer that impedes the downward movement of water; or (2) soils with moderately fine to fine texture and slow infiltration rates. The soils in hydrologic group C have slow water infiltration and transmission rates when wetted. Hydrologic soil group D consists of (1) clay soils with high swelling potential; (2) soils with high permanent water table; (3) soils with clay pan or clay layer at or near the surface; or (4) shallow soils over nearly impervious materials. Hydrologic soil group D is characterized by soils with very slow rates of water infiltration and transmission when wetted. In general, hydrologic soil groups C and D are likely to generate surface runoff. Some soils fall within a range of hydrologic soil groups and are therefore classified as Highly Variable (HV).
Hydrologic soil groups A and B comprise approximately 66.3% of the Oatman project area (Table 7), indicating that the majority of the project area has soils with moderate to high water infiltration and transmission rates, and a low potential to generate surface runoff. When focusing specifically on logging units that would utilize ground-based heavy machinery, hydrologic soil groups A and B comprise 85.5% of the project area, further indicating a low potential to generate surface runoff.

Table 7: Summary of hydrologic soils groups within the project area on NFS land, and on only that land within logging units that would use heavy machinery, as characterized in the Fremont National Forest SRI (Wenzel 1979).

<table>
<thead>
<tr>
<th>Hydrologic Soil Group</th>
<th>Percent of Project Area</th>
<th>Percent of Logging Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47.4</td>
<td>69.6</td>
</tr>
<tr>
<td>B</td>
<td>18.9</td>
<td>15.9</td>
</tr>
<tr>
<td>C</td>
<td>23.5</td>
<td>12.2</td>
</tr>
<tr>
<td>D</td>
<td>9.1</td>
<td>1.8</td>
</tr>
<tr>
<td>HV</td>
<td>1.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Geology
There are a range of landtypes (areas with similar soils, bedrock, landforms, and vegetation) within the project area (Table 4), which are characterized in the Fremont National Forest SRI (Wenzel 1979). Bedrock types include soft to hard basalt, tuff, and andesite.

Road Density
Current road densities within the project area are shown in Table 8. See the Transportation report for a detailed description of road maintenance levels (MLs).

Table 8: Current road densities across the entire project area and on only NFS land within the project area. Both total road density (ML 1-5) and open road density (ML 2-3) are shown.

<table>
<thead>
<tr>
<th>Sub-Watershed</th>
<th>NFS Land (Acres)</th>
<th>NFS Land (miles²)</th>
<th>Total Road Density (mi/mi²)</th>
<th>Open Road Density ML 2-3 (mi/mi²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bear Creek</td>
<td>15,082</td>
<td>23.6</td>
<td>3.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Buck Creek</td>
<td>996</td>
<td>1.6</td>
<td>1.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Oatman Flat</td>
<td>4,910</td>
<td>7.7</td>
<td>2.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Timothy Creek</td>
<td>5,354</td>
<td>8.4</td>
<td>2.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Total NFS Land</td>
<td>26,337</td>
<td>41.3</td>
<td>3.2</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Regulatory Framework
The following documents provide regulatory framework for resource management activities with respect to hydrology and soil and establish applicable standards and guidelines. The potential effects to soil and hydrologic resources from the proposed actions of this project are all compliant with the regulations listed below.

Direction for the management of the planning area comes primarily from the Standards and Guidelines of the Fremont National Forest LRMP (USDA Forest Service 1989).

Fremont National Forest LRMP (USDA Forest Service 1989)
LRMP management goals related to soil and hydrologic resources that are applicable to this project are to:

- maintain or improve the productivity of the soil in all resource management areas
- meet or exceed water quality standards
- improve water quality (by decreasing sediment and late season water temperature)
- maintain water quantity consistent with downstream needs and resource protection
- restore and maintain all riparian areas in a condition which enhances riparian dependent resource values

The objectives of the Fremont LRMP related to soil and hydrologic resources that are applicable to this project are to:

- protect water quality and favorable conditions of flow through the application of Best Management Practices (BMPs)
- reduce sediment and decrease late summer stream temperatures
- reduce stream temperatures by restoring and maintaining shade on stream surfaces and restoring stream channel configurations to narrow and deep
- monitor water quality and riparian condition by projects and by long-term trend analysis to document effects of plan implementation
- minimize contribution of sediment from soil-disturbing activities within the watershed through application of BMPs
- leave a minimum of 80% of an activity area in a condition of acceptable productivity for trees and other vegetation following a land management activity

Anticipated Future Conditions
In 10 Years:
- Noticeable improvement in some degraded riparian zones will be evident at the end of the first decade. Willows, alder, and other deciduous species will give those areas a more brushy look. Consequently, fish habitat will be improved.

In Fifty Years:
- Fisheries habitat would be improved considerably over present conditions. Management would emphasize the restoration, maintenance, and/or improvements of habitat quality on major fish-bearing streams.
- Riparian habitat conditions would be significantly improved with noted improvements in overall water quality. Evidence of eroded streambanks would be notably reduced from
present levels. Minimum streamflows would be maintained on selected streams. Additional improvements would be apparent in presently active eroding gullies. These areas would be restored to dry or wet meadow conditions. Many would provide water flow as a result of improvement measures.

Standards and Guidelines
- Overall road density will not exceed 2.5 miles/mile².
- Maintain or improve soil productivity. A minimum of 80% of an activity area must be left in a condition of acceptable productivity potential for trees and other vegetation, following the land management activity. Do not adversely affect more than 20% of an activity area.
- Soil bulk density may not increase by over 15% (or over 20% for volcanic ash/pumice soils).
- To stay within acceptable levels of soil loss and meet soil management objectives, the minimum percent effective ground cover following cessation of any soil-disturbing activity should be as follows:

<table>
<thead>
<tr>
<th>Erosion Hazard Class</th>
<th>1st Year</th>
<th>2nd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (very slight-slight)</td>
<td>20-30</td>
<td>30-40</td>
</tr>
<tr>
<td>Medium (moderate)</td>
<td>30-45</td>
<td>40-60</td>
</tr>
<tr>
<td>High (severe)</td>
<td>45-60</td>
<td>60-75</td>
</tr>
<tr>
<td>Very High (very severe)</td>
<td>60-75</td>
<td>75-90</td>
</tr>
</tbody>
</table>

Table 9: Minimum percent effective ground cover, as specified in the Fremont LRMP (USDA Forest Service, 1989).

Fremont National Forest Soil Productivity Guide (USDA Forest Service 2002)
This Soil Productivity Guide highlights the importance of consideration of soil impacts that could arise from ground-disturbing management activities, and provides guidance in implementing sound soil conservation and management practices, monitoring impacts of such practices, and maintaining soil productivity.

Inland Native Fish Strategy (INFISH) (USDA Forest Service 1995)
INFISH provides direction for protecting Riparian Habitat Conservation Areas (RHCAs), which are portions of watersheds where riparian-dependent resources receive primary emphasis and management activities are subject to specific standards and guidelines. RHCAs include traditional riparian corridors, wetlands, and other areas that help maintain the integrity of aquatic ecosystems by (1) influencing the delivery of coarse sediment, organic matter, and woody debris to streams, (2) providing root strength for channel stability, (3) shading the stream, and (4) protecting water quality.

There are four categories of RHCAs. Each category has a defined width of the RHCA that is adequate to protect streams from non-channelized sediment inputs and be sufficient to provide
other riparian functions, including delivery of organic matter and woody debris, stream shading, and bank stability. The four categories are:

**Category 1** - Fish-bearing streams: Interim RHCAs consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet including both sides of the stream channel), whichever is greatest.

**Category 2** - Permanently flowing non-fish-bearing streams: Interim RHCAs consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year flood plain, or to the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet, including both sides of the stream channel), whichever is the greatest.

**Category 3** - Ponds, lakes, reservoirs, and wetlands greater than 1 acre: Interim RHCAs consist of the body of water or wetland and the area to the outer edges of the riparian vegetation, or to the extent of the seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance from the edge of the maximum pool elevation of constructed ponds and reservoirs or from the edge of the wetland, pond or lake, whichever is greatest.

**Category 4** - Seasonally flowing or Intermittent streams, wetlands less than 1 acre, landslides, and landslide-prone areas: This category includes features with high variability in size and site-specific characteristics. At a minimum the interim RHCAs must include:

a. the extent of landslides and landslide-prone areas

b. the intermittent stream channel and the area to the top of the inner gorge

c. the intermittent stream channel or wetland and the area to the outer edges of the riparian vegetation

d. for Priority Watersheds the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one site-potential tree, or 100 feet slope distance, whichever is greatest

e. for watersheds not identified as Priority Watersheds, the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one half site-potential tree, or 50 feet slope distance, whichever is greatest

**Standards and Guidelines**

Project and site-specific standards and guidelines listed below would apply to all RHCAs and to projects and activities in areas outside RHCAs that would degrade them. The combination of the standards and guidelines for RHCAs specified below with the standards and guidelines of
existing forest plans and land use plans would provide a benchmark for management actions that reflects increased sensitivities and a commitment to ecosystem management.

Riparian Goals (pages A-1 to A-2): These goals establish an expectation of the characteristics of healthy, functioning watersheds, riparian areas, and associated fish habitats. INFISH identifies several goals for watershed, riparian, and stream channel conditions, which include goals to maintain or restore:

- water quality, to a degree that provides for stable and productive riparian and aquatic ecosystems;
- stream channel integrity, channel processes, and the sediment regime under which the riparian and aquatic ecosystems developed;
- instream flows to support healthy riparian and aquatic habitats, the stability and effective function of stream channels, and the ability to route flood discharges;
- natural timing and variability of the water table elevation in meadows and wetlands;
- diversity and productivity of native and desired non-native plant communities in riparian zones;
- riparian vegetation, to:
  - provide an amount and distribution of large woody debris characteristic of natural aquatic and riparian ecosystems;
  - provide adequate summer and winter thermal regulation within the riparian and aquatic zones; and
  - help achieve rates of surface erosion, bank erosion, and channel migration characteristic of those under which the communities developed.

Riparian Management Objectives (pages A-2 to A-4): These objectives provide the criteria against which attainment or progress toward attainment of the riparian goals is measured. Riparian management objectives that are applicable to this project’s hydrological resources include (Table B1 within INFISH):

- water temperature: 7 day average maximum water temperature below 59°F within adult holding habitat and below 48°F within spawning and rearing habitats;
- bank stability greater than 80%; and
- stream width:depth ratio less than 10 (mean wetted width divided by mean depth)

The following INFISH Standards and Guidelines (Appendix E in USDA Forest Service 1995) are applicable to this project:

- TM-1 (section b): Apply silvicultural practices for Riparian Habitat Conservation Areas to acquire desired vegetation characteristics where needed to attain Riparian Management Objectives. Apply silvicultural practices in a manner that does not retard attainment of Riparian Management Objectives and that avoids adverse effects on inland native fish.
- RF-2: For each existing or planned road, meet the Riparian Management Objectives and avoid adverse effects to inland native fish.
- RF-3: Determine the influence of each road on the Riparian Management Objectives. Meet Riparian Management Objectives and avoid adverse effects on inland native fish.
• RF-4: Construct new, and improve existing, culverts, bridges, and other stream crossings to accommodate a 100-year flood, including associated bedload and debris, where those improvements would/do pose a substantial risk to riparian conditions . . . construct and maintain crossings to prevent diversion of streamflow out of the channel and down the road in the event of crossing failure.

• RF-5: Provide and maintain fish passage at all road crossings of existing and potential fish-bearing streams.

The Organic Administration Act of 1897
This Act established National Forests, with the purpose of improving and protecting the forest and securing favorable conditions of water flows, for the use and necessities of citizens of the United States.

The Multiple Use Sustained Yield Act of 1960
This act authorized the development and administration of the renewable resources of timber, range, recreation, water, and wildlife on national forests for multiple use and sustained yield of the products and services.

These Acts developed the federal, state, and municipal guidelines for controlling water pollution. The Clean Water Act of 1977 directed greater attention to forest BMPs for clean water and stream bank erosion control.

The National Forest Management Act of 1976
This act stresses “. . . the maintenance of productivity and the need to protect and improve the quality of soil and water resources, and avoid permanent impairment of productive capability of land.”

The objectives of this supplement relative to water quality are: “To meet direction in the National Forest Management Act of 1976 and other legal mandates. To manage National Forest System lands under ecosystem management principles without permanent impairment of land productivity and to maintain or improve soil and water quality.”

Executive Orders
The following Executive Orders are applicable to this project:

• Executive Order 12088 requires Federal compliance with pollution control standards (i.e. The Clean Water Act)
Executive Order 11988 requires agencies to avoid adverse impacts associated with the occupancy and modification of floodplains.

Executive Order 11990 requires agencies to avoid adverse impacts associated with the destruction or modification of wetlands.

**Oregon Water Quality Standards**

The state of Oregon is required to establish water quality standards that are approved by the U.S. Environmental Protection Agency (EPA) and regulated by the Oregon Department of Environmental Quality (ODEQ).

**Best Management Practices**

The Fremont LRMP (page 88) refers to the regional-level General Water Quality Best Management Practices – Pacific Northwest Region (USDA Forest Service 1988). In 1998 the Fremont National Forest Hydrologist and Fish Biologist developed Forest-level BMPs for road related activities, and completed consultation with on them with the US Fish and Wildlife Service (USFWS). In 1999 the Forest developed BMPs for timber harvest activities. These Forest-Level BMPs supplement the Regional BMPs and are referenced in Appendix xx.

In 2012 the Forest Service developed a set of National Core BMPs. The National BMP Program consists of four main components: 1) the National Core BMP Technical Guide (Volume 1); 2) the National BMP Monitoring Technical Guide (Volume 2); 3) revised national direction; and 4) a national data management and reporting system. National Core BMPs do not supersede or replace existing and currently used regional, state, national forest or grassland BMPs. Rather, the National Core BMPs are intended to:

- Provide a single structure for agency consistency, accountability, and monitoring;
- Provide general, non-prescriptive direction for protecting water quality in the implementation of land and resource management activities that commonly occur on all NFS lands;
- Require the utilization of site specific prescriptions to achieve water quality protection. State BMPs, FS regional guidance, and land management plans provide more specific direction appropriate for local conditions and water quality goals. This information, along with BMP monitoring results and professional judgment, are to be used to develop site-specific BMP prescriptions to meet the objective of each National Core BMP;
- Ensure that FS staff use best available scientific information to develop site-specific BMP prescriptions, and ultimately, improve water quality on and downstream of NFS lands.

The following Fremont National Forest Best Management Practices (Appendix xx) apply to this project:

Timber Harvest

- T-1: Timber Sale Planning
- T-2: Timber Harvest Unit Design
• T-4: Use of Sale Area Maps for Designating Water Quality Protection Needs  
• T-5: Limiting the Operating Period of Timber Sale Activities  
• T-7: Streamside Management Unit Designation  
• T-8: Streamcourse Protection Implementation and Enforcement  
• T-9: Determining Tractor Loggable Ground  
• T-10 Log Landing Location  
• T-11: Tractor Skid Trail Location and Design  
• T-13: Erosion Prevention and Control Measures During Timber Sale Operations  
• T-14: Revegetation of Areas Disturbed by Harvest  
• T-15: Log Landing Erosion Prevention and Control  
• T-16: Erosion Control on Skid Trails  
• T-17: Meadow Protection During Timber Harvest  

Roads  
• R-1: General Guidelines for the Location and Design of Roads  
• R-2: Erosion Control Plan  
• R-3: Timing of Construction Activities  
• R-7: Control of Surface Road Drainage Associated with Roads  
• R-8: Constraints related to Pioneer Road Construction  
• R-11: Control of Sidecast Material  
• R-12: Control of Construction in RHCAs  
• R-13: Diversion of Flows around Construction Sites  
• R-14: Bridge and Culvert Installation and Protection of Fisheries  
• R-15: Disposal of Right-of-Way and Roadside Debris  
• R-17: Water Source Development Consistent with Water Quality Protection  
• R-18: Maintenance of Roads  
• R-20: Traffic Control During Wet Periods  
• R-21: Snow Removal Controls to Avoid Resource Damage  
• R-23: Decommissioning of Temporary Roads and Landings/Road Closures  
• R-24: Landscape and Hazardous Material  

The following General Water Quality Best Management Practices – Pacific Northwest Region (USDA Forest Service 1988) apply to this project:

Fire Suppression and Fuels Management  
• F-2: Consideration of Water Quality in Formulating Prescribed Fire Prescriptions  
• F-3: Protection of Water Quality During Prescribed Fire Operations  

Watershed Management  
• W-1: Watershed Restoration  
• W-2: Conduct Floodplain Hazard Analysis and Evaluation  
• W-3: Protection of Wetlands
Hydrology and Soils Specialist Report

- W-4: Oil and Hazardous Substance Spill Contingency Plan and Spill Prevention Control and Countermeasure Plan
- W-5: Cumulative Watershed Effects
- W-7: Water Quality Monitoring
- W-8: Management by Closure to Use

Vegetative Manipulation
- VM-1: Slope Limitations for Tractor Operations
- VM-2: Tractor Operation Excluded from Wetlands and Meadows
- VM-3: Revegetation of Surface Disturbed Areas
- VM-4: Soil Moisture Limitations for Tractor Operations

The following National BMPs (USDA Forest Service 2012) apply to this project:

General Planning Activities
- Plan-1: Forest and Grassland Planning
- Plan-2: Project Planning and Analysis
- Plan-3: Aquatic Management Zone Planning

Aquatic Ecosystem Management Activities
- AqEco-1: Aquatic Ecosystem Improvement and Restoration Planning
- AqEco-2: Operations in Aquatic Ecosystems
- AqEco-3: Ponds and Wetlands
- AqEco-4: Stream Channels and Shorelines

Wildland Fire Management Activities
- Fire-1: Wildland Fire Management Planning
- Fire-2: Use of Prescribed Fire

Recreation Management Activities
- Rec-3: Dispersed Use Recreation
- Rec-5: Motorized Vehicle Use Areas

Road Management Activities
- Road-1: Travel Management Planning and Analysis
- Road-2: Road Location and Design
- Road-3: Road Construction and Reconstruction
- Road-4: Road Operations and Maintenance
- Road-5: Temporary Roads
- Road-6: Road Storage and Decommissioning
- Road-7: Stream Crossings
- Road-8: Snow Removal and Storage
- Road-9: Parking and Staging Areas
- Road-10: Equipment Refueling and Servicing
- Road-11: Road Storm-Damage Surveys

Mechanical Vegetation Management Areas
BMP Effectiveness

Ice 2010, stated “Together, effective BMPs and a high rate of BMP implementation result in low non-point source (NPS) impacts and help protect the water quality and beneficial uses of streams, lakes, and wetlands in forested environments.” Ice 2010 also stated “…when effective BMPs are implemented, water quality impacts are minimized.” Ice, 2004 concluded that there is strong evidence that BMPs are reducing water quality impacts by 90% or more. Lynch and Corbett, 1990, stated that overall BMPs were very effective in preventing serious deterioration of stream water quality as a result of forest harvesting. Ice, et al in 1997 stated that BMPs may not be completely effective, but they do provide a level of protection that the states and the Environmental Protection Agency (EPA) judged sufficient to meet the goals of the Clean Water Act. Parker, (no date), stated that “It was determined that the USFS forest practices meet or exceed the state BMPs.” Ice, 2004 states that “Best management practices have evolved from the concept of better land use practices and are widely accepted as the most appropriate method of controlling nonpoint sources of pollution. Still, there is a stigma that BMPs are not as protective as point source controls such as effluent treatment under NPDES permits. Here we argue that BMPs are equally effective and have a documented pattern of evolution and innovation to address ever-increasing demands for tighter control and new water or environmental issues.”

Forest Service (FS-990a, 2012) National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide discusses the history and required use of BMPs to meet the intent of the Clean Water Act. “The National BMP Program was developed to improve agency performance and accountability in managing water quality consistent with the Federal Clean Water Act (CWA) and State water quality programs.” “Current Forest Service policy directs compliance with required CWA permits and State regulations and requires the use of BMPs to control nonpoint source pollution to meet applicable water quality standards and other CWA requirements. The Forest Service strategy for control of nonpoint source pollution is to apply appropriate BMPs using adaptive management principles.” FS R5 has monitored BMP Implementation and effectiveness. From fiscal year 2003 to 2007, the FS R5 completed 2,861 onsite evaluations; an average of 572 per year. The Forest Service rated BMPs as implemented on 86 percent of those evaluations and effective on 89 percent. Overall, 93 percent of the BMPs that were rated as implemented were also judged effective.

Alternative Descriptions

Alternative 2, and Alternative 3, the two action alternatives propose a combination of conifer thing, prescribed fire, snag retention, old growth habitat improvements for wildlife, mountain mahogany restoration, wildlife forage openings, shrub vegetation treatments, aspen and black
cottonwood stand restoration, meadow restoration, riparian habitat conservation area restoration. Spring restoration, and botanical and cultural site protection. Details regarding the action alternatives are contained in Chapter 2 of this EA.

Road Density
Proposed changes to road density under the Oatman Restoration Project are shown in Table 10.

Table 10: Current and proposed road densities on NSF lands within the project area. Total road density includes all maintenance level (ML) 1-5 roads, while open road density includes only ML 2-3 roads (see the Transportation report for a detailed description of road maintenance levels).

<table>
<thead>
<tr>
<th>Subwatershed</th>
<th>NFS Land (miles²)</th>
<th>Current Total Road Density (miles/miles²)</th>
<th>Proposed Total Road Density (miles/miles²)</th>
<th>Current Open Road Density (miles/miles²)</th>
<th>Proposed Open Road Density (miles/miles²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bear Creek</td>
<td>23.6</td>
<td>3.8</td>
<td>2.6</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Buck Creek</td>
<td>1.6</td>
<td>1.7</td>
<td>1.3</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Oatman Flat</td>
<td>7.7</td>
<td>2.4</td>
<td>1.8</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Timothy Creek</td>
<td>2.0</td>
<td>2.4</td>
<td>2.0</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Total Project Area</td>
<td>41.3</td>
<td>3.2</td>
<td>2.3</td>
<td>1.7</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Effects Analysis
The potential direct, indirect, and cumulative effects to soil and hydrologic resources were analyzed and are reported below. When assessing potential impacts to soil and hydrologic resources, short-term refers to 5 years or less while long-term refers to greater than 5 years.

Potential Impacts to Soil and Hydrologic Resources
Vegetation management projects that include logging and prescribed fires have the potential to impact both soil and hydrologic resources due to possibility of soil compaction, erosion, and/or displacement (Luce and Black 1999; Ares et al. 2005; Moore and Wondzell 2005; Scott 2007), and changes in streamflow, channel morphology, and/or water quality (Luce and Black 1999; Scherer and Pike 2003; Moore and Wondzell 2005; Janisch et al. 2012).

Soil Compaction:
Soil compaction is the process in which soil pore space decreases and soil bulk density increases. Compacted soils can be identified by the presence of platy soil structures with horizontal alignment or massive soil with no structural units present, which contrast with healthier soils with three-dimensional alignment and blocky and granular structure (USDA Forest Service 2009). As contiguity and prominence of platy structures increases, so does severity of compaction and degree of root growth restriction. Soil compaction can occur during timber
harvest from use of heavy logging equipment, increased use of existing roads, and construction of temporary roads (Luce and Black 1999). The degree of compaction is dependent upon operational practices and site conditions, and generally increases with increasing soil moisture (Ares et al. 2005; Moore and Wondzell 2005). As soils become compacted, the amount of water that can infiltrate soil is reduced (Elliot 1999), which can increase surface runoff and erosion and decrease groundwater recharge. However, understory plant growth and root expansion can help to mitigate soil compaction caused during timber harvest (Castellano and Valone 2007). The extent of soil compaction can also be reduced by frequent freeze-thaw cycles, however this process is generally limited to only surface soil layers.

**Soil Erosion:**
Erosion in this section will be discussed in terms of soil surface erosion outside of stream channels (stream channel erosion is discussed in the upcoming Channel Morphology section). Soil erosion occurs as soil particles are detached and transported by wind and water. Due to the high density of forested areas in the project area, wind erosion is minimal. Removal of vegetation and organic residue during timber management increases susceptibility of soil to transport by overland flow as well as to rain splash erosion (soil particle detachment due to impact of rain drops). Additionally, road networks used in timber harvest operations can capture and concentrate shallow subsurface flow and increase channel networks, leading to increased sediment delivery to the stream channel (Foltz 1995a; Luce and Black 1999). While timber harvest and associated soil disturbances can lead to a short-term increase in soil erosion, the increase in shrub and herbaceous groundcover that often follows timber harvest generally leads to increased soil water infiltration. This in turn can decrease overland flow, which can lead to a long-term decrease in soil erosion.

Fire can also lead to increased soil surface erosion by making the soils hydrophobic (water repellant), which can impede water infiltration (Letey 2001) and increase overland flow. Soil hydrophobicity can be severe and long-lasting following high intensity fires, however, it is generally short-lived following low intensity fires (such as those that are intended with prescribed fires) (DeBano 2000).

Encroachment by junipers (and other conifers) into meadows can also increase soil erosion. Junipers often out-compete shrub and herbaceous vegetation for sunlight and nutrients, which can result in increased barren ground following juniper encroachment and higher soil erosion potential (Pierson et al. 2007; Peterson and Stringham 2008; Pierson et al. 2010). Reduction in shrub and herbaceous ground cover also reduces infiltration capacity of soil, which further increases potential for overland flow and surface erosion.

**Soil Displacement**
Soil displacement is the removal and horizontal movement of soil by mechanical forces, which can result from use of ground disturbing equipment during timber harvest (Scott 2007). Soil displacement can concentrate water and damage soil structure, and lead to reduced infiltration and root growth, and increased erosion. Further, when topsoil is displaced, soil productivity diminishes.
Soil Productivity
Timber harvest can affect soil productivity due to soil compaction, erosion, soil displacement, and vegetation removal. For example, increased surface erosion following vegetation removal can remove or redistribute topsoil, which is the most fertile soil layer. Erosion of shallow soils and soil compaction can decrease the area of the root zone and the amount of air, water, and nutrients available to plants. Further, fires can volatilize nutrients that are necessary for plant growth. These impacts are interrelated (i.e. they affect and are affected by each other) (Elliot 1999), and therefore, the impacts of the Oatman Restoration Project on soil productivity will not be discussed or analyzed separately in this document but rather will be addressed through analysis of the aforementioned factors.

Streamflow
The amount and timing of streamflow is a function of the amount, timing, and intensity of precipitation and snowmelt, as well as the amount, type, and spatial distribution of vegetation in the watershed. When tree densities increase beyond that which occurred historically, understory shrub and herbaceous vegetation cover often decreases. This can result in decreased soil water infiltration and increased overland flow, which in turn can lower the groundwater table, increase peak streamflow, and reduce stream baseflow.

Timber harvest can also lead to both short- and long-term changes in streamflow (Scherer and Pike 2003; Moore and Wondzell 2005). Peak streamflow can initially increase following timber harvest due to reduction in water uptake from soil by vegetation as well as increased overland flow. However, the increase in shrub and herbaceous ground cover that often follows timber harvest can lead to long-term increased soil water infiltration and reduced overland flow, and thus less extreme peak flows. The short-term reduction in infiltration following timber management activities can also decrease groundwater storage, which can lead to short-term decreases in baseflow. However, the reduction in canopy cover decreases the amount of snow intercepted by the canopy and lost to evaporation and sublimation (Stottlemeyer and Troendle 2001; Storck et al. 2002; Ellis et al. 2013). Greater snow accumulation on the ground, coupled with long term increases in infiltration, has the potential to increase groundwater storage and lead to higher and more sustained stream baseflows.

The increased use of existing roads and construction of temporary roads during logging activities can also contribute to increased peak streamflows during and following timber harvest due to increased delivery of water to the stream channel across compacted road surfaces. Increased peak streamflow and decreased stream baseflow can also occur following large scale, high intensity wildfires due to decreased soil water infiltration and increased overland flow (Neary et al. 2005).

Juniper encroachment into meadows can also impact streamflow. The decrease in shrub and herbaceous vegetation following juniper encroachment can lead to reduced groundcover, increased overland flow, and lower soil water infiltration and storage (Pierson et al. 2007; Petersen et al. 2008). This reduction in ground cover can also lead to higher soil temperatures and therefore higher evaporation (Breshears et al. 1998). The combination of decreased soil
water infiltration and increased evaporation following juniper encroachment can reduce the amount of water in soil and therefore the amount of water available to recharge groundwater and sustain stream baseflows.

**Channel Morphology**
Stream channel morphology is defined by the cross-sectional and longitudinal shape of the channel, and channel substrate size and distribution. Timber harvest can impact stream channel morphology due to potential increases in stream sediment delivery, erosive peak streamflows, and accelerated streambank erosion. Timber harvest can also increase sediment delivery to streams due to increased overland flow and soil erosion. Additionally, road networks used during timber harvest operations can capture and concentrate shallow subsurface flow and increase channel networks, leading to increased sediment delivery to stream channels (Foltz 1995a; Luce and Black, 1999). However, long-term increases in soil water infiltration following timber management generally leads to decreased overland flow and erosive peakflow, which can result in long-term improvements in stream channel morphology such as increased bank stability and reduced streambank erosion.

**Water Quality**
Timber harvest and fires can impact water quality parameters such as water temperature, turbidity, and nutrient concentrations. Stream temperatures can increase following timber harvest or fires due to removal of vegetation that provided shade to the stream (Bartholow et al. 2000; USDA Forest Service 2005; Anderson et al. 2007; Janisch et al. 2012). Stream water turbidity, which is a measure of the “cloudiness” of water, and stream nutrient concentrations often increase following logging activities or fires due to increased erosion and associated sediment delivery to streams.

**Direct and Indirect Effects**
Direct effects are defined as effects which are caused by the action and occur at the same time and place, while indirect effects are effects which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. The bounds of analysis for determination of direct effects of the Oatman Restoration Project to soil and hydrologic resources are the project area and the time period of project implementation. The bounds of analysis for determination of short-term (5 years or less) indirect effects is the project area plus approximately 2 miles downstream of any stream that flows through the project area, and the time period of project implementation plus an additional 2 weeks. This spatial area and time period were selected because potential impacts to hydrologic resources could extend downstream of the project area and/or beyond the time period of project implementation, but would be expected to dissipate within the additional stream distance and time period specified. For determination of long-term (more than 5 years) indirect effects, the time period is extended to 5 years beyond project implementation, and the spatial area is the same as for short-term indirect effects.
Measurement Indicators
Measurement indicators are presented to compare and contrast the potential effects of each alternative to soil and hydrologic resources. Indicators were selected based on professional judgment and a thorough literature review. The potential impacts of the proposed actions under each alternative to soil and hydrologic resources are disclosed quantitatively using measurement indicators shown in Table 11.

Table 11: Measurement indicators and quantification by alternative used to determine potential effects.

<table>
<thead>
<tr>
<th>Measurement Indicator</th>
<th>Alternative 1 (no-action)</th>
<th>All Action Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles of stream (NFS land)</td>
<td>0</td>
<td>34.1</td>
</tr>
<tr>
<td>Miles of temporary roads</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Miles of road decommissioned</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Miles of road closed</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Total road density (mi/mi²)</td>
<td>3.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Acres of land logged</td>
<td>0</td>
<td>12,177</td>
</tr>
<tr>
<td>Acres of land burned</td>
<td>0</td>
<td>26,455</td>
</tr>
</tbody>
</table>

Alternative 1: (no-action)
Under Alternative 1, no logging or prescribed burning would occur (Table 11), and there would be no potential for negative impacts to soil or hydrologic resources related to these activities. However, without logging or prescribed fire, the extent of the canopy cover would likely continue to increase while shrub and herbaceous ground cover would continue to decrease. Therefore, the ability of water to infiltrate the soil and recharge groundwater would continue to decrease over time as groundcover is further reduced, and the risk for decreased stream baseflows and increased peak streamflows and erosive overland flow would continue.

Under Alternative 1, uncharacteristically high fuel loads and their risk of creating high intensity and high severity wildfires would remain (DeBano et al. 1998). If a high severity wildfire were to occur, there would likely be negative impacts to both soil and hydrologic resources. For example, extreme heat from high severity fires could consume soil organic layers and destroy soil structure. High heat from wildfires could also cause the soil to become hydrophobic, in which the soil repels water and causes an increase in the amount of water that flows over the soil surface (Debano 2000; Letey 2001). Soil hydrophobicity, coupled with the decrease in plant ground cover and root networks, would decrease soil water infiltration rates and lead to increased surface erosion and sediment delivery to streams, and decreased water quality. The decrease in soil water infiltration would also lead to a decline in the groundwater table and a subsequent
decrease in stream baseflows. Further, velocity of peak stream flows would have potential to increase, which could lead to streambank erosion and degradation.

Implementation of Alternative 1 would likely lead to continued conifer encroachment into meadows and RHCA, which would lead to a reduction in shrub and herbaceous ground cover and a subsequent decrease in soil water infiltration (Pierson et al. 2007, 2010; Peterson et al. 2008). Decreased soil water infiltration would have the potential to decrease groundwater table height and reduce stream baseflows. Increased overland flow and sediment delivery to streams would likely occur. Encroachment of conifers into RHCA would also increase the probability that a high intensity wildfire would burn vegetation adjacent to streams, which would increase soil erosion and stream sediment delivery and decrease stream shading. Further, no stream or meadow restoration would occur, and degradation of impaired streams and meadows would likely continue.

No temporary roads would be constructed under Alternative 1 (Table 11), and potential negative impacts to soil and hydrologic resources from road construction would not occur. However, road decommissioning would not occur, total road densities would remain above the Fremont National Forest LRMP (USDA Forest Service 1989) standard of 2.5 miles/mile² (Table 11), and the potential reduction in stream sediment delivery from road surfaces would not occur.

In summary, implementation of Alternative 1 would pose no short-term risks to soil or hydrologic resources. However, long-term increases in understory groundcover and soil water infiltration that would likely occur following logging and prescribed burning would not occur, and the risk of a high severity wildfire and associated negative impacts to soils, water quality and quantity, and stream geomorphology would remain.

Alternative 2 (proposed action)
Implementation of Alternative 2 would likely lead to some short-term negative impacts to soil and hydrologic resources. Approximately 12,177 acres of land would be logged using heavy machinery (Table 11), and some soil compaction is likely. According to the Fremont National Forest SRI (Wenzel 1979), 17.7% of the soil within the project area has a high potential for soil compaction; this number is reduced to 2.7% (approximately 343 acres) when focusing on only areas in which heavy ground-disturbing equipment would be used (Table 6). Therefore, only a small percentage of the project area would be highly susceptible to short-term increased soil compaction. Further, the extent of any soil compaction that may result from implementation of Alternative 2 would likely decrease over time due to naturally occurring mitigation processes such as frequent freeze/thaw events and root growth and expansion, and long-term soil compaction would not be likely throughout the project area.

Widespread soil displacement resulting from logging activities is unlikely as there is high potential for soil displacement on less than 10% of the project area (Table 6). There is high potential for erosion across 42% of the project area (Table 6); this number is reduced to 19.9% when focusing on only logging units that would utilize heavy ground-disturbing machinery. While some soil erosion is likely to occur, use of BMPs would reduce potential for soil erosion, and existing groundcover would help protect soil from treatment activities. The small stream
drainage density within the project area also indicates low potential for stream sediment delivery. No logging would occur on slopes greater than 35%, and use of low pressure ground equipment would also reduce potential soil compaction and erosion (Foltz 1995b; Foltz and Elliot 1996).

Short-term negative impacts to streams within the project area may occur under implementation of Alternative 2 due to potential soil compaction, erosion, and sediment delivery to streams. However, high sediment yield potential exists in only 2.3% of the area that would be logged using heavy equipment (Table 6), and the majority of logging would occur in forested stands away from streams. Construction and use of temporary roads across streams would be minimal and would only be permitted when streams were at low flow or dry. All streams within the project area are ephemeral or intermittent (Table 2), which further reduces potential for downstream sediment transport. While it is possible that sediment could reach streams from upland logging units, use of BMPs would reduce the likelihood of increased stream sedimentation.

Hand thinning areas adjacent to streams could initially reduce stream shading and increase stream temperatures. However, trees would not be thinned adjacent to stream channels, and increased solar radiation on the water surface related to thinning would be unlikely. Further, increased shrub and herbaceous ground cover that often follows thinning projects would lead to increased soil water infiltration and groundwater storage, which can result in cooler stream temperatures. Use of heavy machinery would not occur adjacent to stream channels (with the exception of stream restoration projects), and streambank stability would not be negatively impacted from timber harvest operations. The reduction in canopy cover throughout the project area would also decrease the amount of snow intercepted by the canopy and lost to evaporation and sublimation (Storck et al. 2002; Stottlemyer and Troendle, 2001). Greater snow accumulation on the ground, coupled with long-term increases in infiltration, would increase groundwater recharge and storage and lead to higher and more sustained stream baseflows and reduced risk of extreme, highly erosive peak flows.

Stream and meadow restoration projects such as headcut repairs and culvert replacement/removal have potential to lead to short-term negative impacts due to use of heavy machinery within or adjacent to streams and meadows. However, use of BMPs would reduce potential for negative impacts. These projects would lead to long-term improvements to streams and meadows by restoring and improving hydrologic function. For example, headcut repairs and culvert replacements would slow stream velocities, reduce stream erosion, and increase groundwater storage.

The construction of approximately 5 miles of temporary roads could lead to soil compaction of the road surfaces and increased overland flow and erosion (Ares et al. 2005; Moore and Wondzell 2005). However, these temporary roads would be constructed following applicable BMPs (Appendix xx), used for only a short duration, and would be decommissioned following timber harvest and hauling activities. Therefore, long-term negative impacts from temporary road construction and use are not likely. Under Alternative 2, 52 miles of road would be decommissioned and 38 miles of road would be closed which would reduce both open and total road densities (Table 11). This would reduce potential for sediment from roads entering stream channels. The proposed road decommissioning would also reduce total road density of from 3.6
to 2.3 miles/mile$^2$ (Table 11), which would reduce road-related erosion and meet the Fremont LRMP (USDA Forest Service 2009) threshold of 2.5 miles/mile$^2$. 2.3 miles of existing user-created non-system roads would be added to the NFS roads inventory as Maintenance Level (ML) 2 (2.0 miles) and ML1 (0.3 mile).

Prescribed burning would occur on approximately 26,455 acres (Table 11) including 270 acres in MA 15 Riparian. The riparian areas are ephemeral streams which only flow during snow melt and in response to summer thunderstorms. The thinning would still allow for cover in wildlife corridors. The wildlife report discusses these corridors in more detail. This has potential to lead to some negative impacts to soil and hydrologic resources, such as hydrophobic soils and increased stream sediment delivery. However, prescribed burning would occur under conditions in which fire would burn at low severities, and widespread negative impacts would be minimal. In many areas, prescribed burning would result in an increase in shrub and herbaceous groundcover, which would increase soil water infiltration and storage and lead to positive impacts to soil and hydrologic resources. Use of prescribed burning would also reduce potential for high intensity wildfires across the landscape. Prescribed burning is also discussed in the fire/fuels report.

Monitoring of prescribed fire and WFU in dry ponderosa pine forests in Utah by the hydrologist shows that the areas had limited hydrophobic soils, low high burn severity (2.2% of burn area), and that revegetation occurred quickly (Goodman 2008). Observations of high and moderate burn severity from Barry Point fire show grass were reemerging quickly and needles providing groundcover shortly after the fire was out. Monitoring from Toolbox fire shows a high percentage of groundcover (grasses, shrubs) in high severity areas three years after the fire was out (Goodman 2013). Since the plan is to have a low severity fire the vegetation would not be impacted as much and would recover much quicker than in these high severity areas. More details about prescribed fire and water quality can be found in Hydrology Appendix A.

Treatments in riparian areas (RHCA) would include some thinning (acres 1472) and prescribed fire (270 acres). The areas that are thinned would have the material piled and burned. To protect water quality no piles would be within the RHCA. Prescribed fire within the RHCA may result in some short term increases in erosion or sediment getting into the stream. Since the prescribed fire is intended to be a low severity fire any changes in sediment or erosion would be short term and may not be noticeable due to natural variations in stream flow and erosion/sediment. To protect water quality no active ignition would occur within RHCA using drip torches or similar gas/diesel fuel ignition type devices. Prescribed fire would be allowed to back into the riparian areas. “Prescribed fire conditions produce lower fire intensities and lower fire severity leading to reduced potential for subsequent damage to soil and water resources.” (RMRS GTR 42 vol 4. 2005). RMRS GTR 231, published in 2010 stated “Prescribed fires are typically intentionally set during times when flame lengths are expected to be low, fire residence times are expected to be short, soil heating is expected to be low, and the effects of prescribed fires on soil properties and limited in severity and extend.” RMRS GTR 231 also stated “Low severity fire has a minimal effect on soil biota because maximum temperatures are generally nonlethal, except for the upper litter layer and consumption of the forest floor habitat is limited.”
As stated earlier in this report and in other specialist reports, the vegetation in the area has seen an increase in juniper which can out compete other desired riparian vegetation including willows. Removal of some of the juniper either through hand cutting and/or prescribed fire may result in some short term increases in bare ground, erosion, runoff and sediment into the channels but the long term would see an increase in riparian vegetation and improved stream and riparian vegetation conditions.

Under implementation of Alternative 2, some trees greater than 21” dbh, including ponderosa pine, would be harvested (which would require Forest Plan amendments). It is important to note that trees greater than 21” dbh would only be harvested if they fit guidelines presented in Appendix xx, and the number of large trees removed would be small relative to the number of large trees that would not be harvested. Harvest of some trees greater than 21” dbh would lead to improvements in groundwater storage due to reduction in evapotranspiration. Further, removal of some large trees would increase shrub and herbaceous groundcover, which would reduce the amount of bare soil and increase soil water infiltration and storage. Removal of some large trees would also increase the amount of snow reaching the ground, which would further increase groundwater storage.

As part of the action alternatives it is proposed to place up to four troughs along the edges of Antelope Flat (Figure 2 Range report), extending an existing system originating at Antelope Well. The troughs would be above ground, each supported on a concrete base with a footprint of up to 350 square feet; and connected by approximately 3.5 miles of 1½ inch diameter polyethylene pipe installed in a 5 inch wide trench, up to 10 inches deep. Float valves would prevent overflow and the system would be purged in winter to avoid freezing damage. These troughs would provide water to the Bear Flat and Buck Creek Allotments with improvement of livestock distribution and reduction in possible effects to riparian systems.

A new storage tank has been installed within 400 feet of Antelope Well, but the pipe has not yet been run to the tank. Running the pipe to the new storage tank and ceasing use of the current storage tank that is no longer efficient at holding water will also be part of this proposed action. Once operational, this tank could be used to fill tenders/engines if water is needed for fire suppression nearby.

In summary, implementation of Alternative 2 would likely lead to minor short-term negative impacts such as soil compaction and erosion, but would lead to long-term improvements to soil and hydrologic resources when compared to Alternative 1, such as increased understory groundcover and soil water infiltration, and a decreased risk for high intensity wildfires.

Alternative 3
The potential for short-term negative impacts to soil and hydrologic resources would be the same as that which could occur with implementation of Alternative 2. There would be potential for a slight reduction in soil compaction by not harvesting some trees greater than 21” dbh. However, these additional trees would be logged from within the same units proposed under Alternative 2, and no additional temporary roads or landings would be constructed (Table 11). Therefore, the potential decrease in extent of soil compaction would be minimal and likely not measurable.
Compared to Alternative 2, implementation of Alternative 3 would reduce the potential benefits to soil and hydrologic resources. For example, trees greater than 21” dbh would continue to outcompete native understory vegetation, and bare ground cover would likely increase. Encroachment of large trees into meadows would continue. The amount of snow reaching the ground surface would also be reduced relative to Alternative 2, which would further reduce soil water infiltration and groundwater storage.

In summary, compared to Alternative 2, implementation of Alternative 3 would have similar short-term negative impacts, but long-term improvements to soil and hydrologic resources would not be as great.

**Cumulative Effects**
Cumulative effects are defined as the impact on the environment which results from the incremental impact of the action when added to other past, present, or reasonably foreseeable future actions. The physical bound of analysis for determination of potential cumulative effects to soil and hydrologic resources are the sub-watersheds in which the project area is located (Figure 1), and the temporal bound is 10 years from beginning of project implementation. Past, present, and reasonably foreseeable activities in the sub-watersheds are listed in Appendix xx and include livestock grazing, road construction and maintenance, invasive plant management, and continued land management such as commercial and non-commercial thinning and prescribed burning.

**Alternative 1 (no-action)**
Cumulative effects analysis examines the effects of the proposed action combined with the effects of past, present, and reasonably foreseeable future actions. Therefore, there are no cumulative effects under the no-action alternative.

**Alternatives 2 and 3**
The cumulative effects of implementation of Alternative 2 or 3, combined with past, present, and reasonably foreseeable future actions (thinning, logging, prescribed fire, riparian area thinning, temporary road construction, road closures, road decommissioning, grazing, range improvements, and spring restoration) within the sub-watersheds that encompass the project area would be short-term increases in soil compaction, erosion, and sediment delivery to the stream. However, not all actions would occur at once, and spatial and temporal separation of ground-disturbing activities would minimize the overall impact across the entire project area at one time.

The long-term cumulative effects of the implementation of Alternatives 2 or 3 would be decreased surface runoff and erosion, and increased shrub and herbaceous groundcover, snow accumulation, soil water infiltration, groundwater recharge and storage, water quality, and overall soil and hydrologic function. Further, there would be reduction in the probability of large scale high intensity wildfires, and associated negative impacts to soil and hydrologic resources.
Climate Change
There is potential for projected changes in climate to impact hydrologic regimes within the project area. In the western United States, many changes in hydrologic regimes have been attributed to changes in climate. For example, as average annual temperature has increased, average snowpack depth has decreased (Mote et al. 2005; Stewart et al. 2009), peak streamflow is occurring 1 to 3 weeks earlier (McCabe and Clark 2005; Regonda et al. 2005; Stewart et al. 2004, 2005; Reiman and Isaak 2010), and a higher proportion of precipitation now falls as rain versus snow (Knowles et al. 2006; Chang and Jung 2010). In the Klamath Basin, which is adjacent to the Oregon Closed Basin in which the project area exists, summer streamflow has declined 38% over the last 50 years, and snowpack has decreased 40% at many locations (Chang and Jung 2010).

With implementation of Alternative 1, the no-action alternative, the landscape would continue to be susceptible to potential negative impacts of climate change to hydrologic regimes. With implementation of both of the action alternatives, the landscape has the potential to become more resilient to climate change. For example, reducing tree densities across the landscape would lead to increased snow accumulation, soil water infiltration, and groundwater storage. This in turn would lead to cooler and more sustained summer streamflow, and a longer period of streamflow within intermittent streams throughout the project area.

Project Design Criteria
1. The Best Management Practices presented in the above “Regulatory Documents” section of this report will be adhered to.
2. Mechanical entries into riparian and meadow areas will be minimized to protect sensitive soils from compaction, erosion, and displacement.
3. Ground pressure of mechanized equipment will not exceed 7.5 psi.
4. Go-to machines (i.e., feller-bunchers that drive up to each individual tree) will generally not be permitted unless the soil is frozen, snow covered, or under dry conditions, as discussed in the Fremont National Forest Soil Productivity Guide.
5. Because of the predominance of rocky, moderately deep soils and the risk of damaging the root system of larger trees not removed during activities, subsoiling would be utilized sparingly on roads proposed for decommissioning.
6. No equipment refueling or maintenance will occur within riparian and meadow areas or near stream crossings.
7. All disturbed areas (e.g. temporary roads and landings) will be restored as closely as possible to pre-disturbance contours upon project completion.
8. Project activities will be monitored to determine the effectiveness of the protection measures and BMPs associated with this project. If monitoring reveals that activities are causing adverse effects, immediate corrective measures will be taken to eliminate the adverse effect.
9. To the greatest extent possible/feasible all fireline will be restored to pre-disturbance contours. All fireline rehabilitation will occur in the same calendar year that the burning is implemented.
10. In the event that a temporary road crosses an intermittent stream channel, construction, use, and decommissioning of the road will occur when the stream channel is dry or at low
flow. The Hydrologist will be consulted with if there is a question as to whether streamflow is sufficiently low to permit road work and/or logging activities.

**Monitoring Requirements**

Soil monitoring, following the methods in the Forest Soil Disturbance Monitoring Protocol (USDA Forest Service 2009) should be conducted in some logging units (as determined by the hydrologist/soil scientist) to determine the extent of soil impacts following ground-based logging disturbance. Monitoring should occur pre-implementation, within 1-2 years following implementation, and approximately 5 years after implementation. If detrimental soil conditions are found during soil monitoring, corrective actions would be taken to reduce or eliminate adverse effects. For any stream or meadow restoration activity, permanent photo-points should be installed, and photographs should be collected every 1-2 years at these locations. In addition, BMP monitoring would occur at some locations to determine BMP effectiveness.
References Cited


Ice, George. (no date). Are Forestry Best Management Practices (BMP”s) Effective?


http://www.deq.state.or.us/wq/assessment/rpt0406/search.asp


