drilled, the surface would not be disturbed and there would be no effect on wildlife.

5. Antone Well Site

Direct and Indirect Effects

The effects would be the same as those described for Antone in Alternative 2.

Cumulative Effects for the Gravelly Planning Unit - Alternative 7

General cumulative effects for Alternative 7 would be the same as those discussed under Alternative 1. Alternative 7 would disturb the surface at all 5 hypothetical well sites (south drill pad and road would be excluded for the West Fork Site). Alternative 1 would disturb 4 of the 5 sites. The magnitude of effects would be slightly greater for Alternative 7 than for Alternative 1 because Alternative 7 places disturbance in the Antone area while Alternative 1 does not. Because the West Fork wells are located so close together, the effects on wildlife from drilling two wells would be nearly the same as drilling all three wells.

LIMA PLANNING UNIT

6. Sourdough Well Site

Direct and Indirect Effects

The effects would be the same as those described for Sourdough in Alternative 1.

7. Lima Peaks Well Site

Direct and Indirect Effects

The effects would be the same as those described for Lima Peaks in Alternative 1.

8. Sawmill Well Sites

Direct and Indirect Effects

For the west drill site and access road, the effects would be the same as those described for Alternative 1. The central and south access roads and drill sites fall within lands bearing the NSO stipulation. The central and south wells would not be drilled, the surface would not be disturbed and there would be no effect on wildlife.

9. East Creek Well Site

Direct and Indirect Effects

The effects would be the same as those described for East Creek in Alternative 1. The well site and road are stipulated NSO so the well would not be drilled, the surface would not be disturbed and there would be no effect on wildlife.

Cumulative Effects for the Lima Planning Unit - Alternative 7

General cumulative effects for Alternative 7 would be the same as those discussed under Alternative 1. Alternative 7 would disturb the surface at 3 of the 4 hypothetical well sites (central and south Sawmill drill pads would be excluded). Alternative 1 would disturb 3 of the 4 sites as well, but includes all Sawmill Well Sites. Therefore, the magnitude of effects would be slightly less for Alternative 7 than for Alternative 1.

For the discussion of wildlife effects, the three Sawmill sites are counted as one site. Because the Sawmill wells are located so close together, the effects on wildlife from drilling one or two wells would be nearly the same as drilling all three wells.

PIONEER PLANNING UNIT

10. Glendale Well Site

Direct and Indirect Effects

The effects would be the same as those described for Glendale in Alternative 1.

Cumulative Effects for the Glendale Analysis Area - Alternative 7

Cumulative effects for Alternative 7 would be the same as those discussed under Alternative 1.

SENSITIVE PLANTS

Based on records compiled by the Montana Natural Heritage Program, the following hypothetical well sites would have possible sensitive species impacts: Crockett Lake, Cliff Lake, Sawmill sites (3), and the Glendale site. This is based on a review of occurrence data, not field review of the well sites on the ground. The remaining sites might have impacts as well, but none are obvious from occurrence data review. These estimates are for the well sites. Roads are presumed to have the same or greater probability for impacts.

Forest-wide, there are no known sensitive plant populations occupying areas larger than about 5 acres. Therefore, under Standard Terms, any operation could be forced to avoid any occurrence of a sensitive plant species.

A Biological Assessment is included as Appendix O of this EIS. In the BA, impacts on sensitive plants are described in greater detail.

SOILS

RECOMMENDED MITIGATION

Sites Which Are Projected to be Dry Holes

Plants would be eliminated from roads and drill-sites for the duration of exploration. Restoration must ensure primary and secondary succession will occur normally, given the climate and restored site. Plant material/seed must be native species with or without short-residence annuals or perennials. Short-residence species are those which will either not reproduce well, or succumb easily to successionary and competition pressures from more adapted, native species. They can be used to fill a short-term niche, for example, to serve as the leguminous species in an overall revegetation strategy. All native species must be selected using the genetic guide and strategy similar to that outlined by Hamrick and Godt, 1989; and Millar and Libby, 1989. Control of introduced species like knapweed must be done until the site contains a species composition and cover equal to an ecological status (similarity) of 25 or more, compared to the potential natural vegetation, or to the predisturbance vegetation.

EFFECTS ON INDIVIDUAL WELL SITES

Introduction

Well Site Area Direct and Indirect Effects

The effects described here are those associated with the well site and vicinity, up to about a mile in diameter, plus the area containing the access roads. Considered are soil resources and associated water resources outside of natural drainage ways (uplands).

The lease terms and stipulations which apply to each alternative are displayed in Table II-4, page II-16.

The criteria used to describe damage to soil resources, as discussed in Chapter II, are: 1) type and severity of potential soil erosion as sheet, rill, gully, or slope mass failure. The unit of measure is the probability of occurrence beyond natural rates. 2) potential for contamination by chemical and degree of hazard. The unit of measure is the probability of contamination by area and depth. 3) soil displacement and/or compaction. The unit of measure is area impacted.

For perspective, to access all well sites, approximately 24.8 miles of roads would have to be constructed. Given the hillslopes encountered, this equates to approximately 107 acres of soil disturbance as roads (cutslope, road surface, fill slope). This estimate is assuming a fourteen-foot road surface with a drainage ditch. Assuming the same standard of road would be constructed to each well, this amount of road would be built under any alternative that has either "CSU", or "Standard Term stipulations" for soil compaction and/or displacement. An additional 70 acres would be stripped for drill pads.

Well Site Area Cumulative Effects

Damage from oil and gas exploration and oil field development across the forest, concurrent with existing and foreseeable uses and development, amounts to cumulative effects. For plant and soil resources, the parameters assessed to describe cumulative effects are soil development, including soil loss and effects on processes like geochemical cycling; soil productivity and plant production; and plant succession and biodiversity.

Cumulative impacts for upland soil and water resources, for each RFD well site are described following direct and indirect effects. This cumulative effects area is the same as the analysis area for direct and indirect effects. Typically, cumulative effects consider existing or proposed roads other than those for the oil and gas activity, and livestock grazing. Timber cutting and mining effects are not considered if they are not in the analysis area.

Mitigation techniques needed to make the assessments of cumulative effects valid include: appropriate design of roads and drill pads; obliteration of roads following the life of the developments; and reclamation standards. The reclamation standards include: control of the source of plant material and seed (genetic suitability); control of species, planting rate and methods used, seed bed preparation method, and quality and handling of the topsoil available.

ALTERNATIVE 1

In Alternative 1, roads, streams, and lakes are buffered 500 feet by NSO. Trails are buffered 200 feet by NSO. Slopes over 65%, areas of mass failure, and areas prone to failure on slopes over 35% are stipulated NSO. Areas sensitive to soil compaction are stipulated CSU and stable slopes from 30-65% follow Standard Lease Terms.

GRAVELLY PLANNING UNIT

1. Crockett Lake Well Site

Under Alternative 1, "Standard Lease Terms" apply on this site, except for sensitive soils, where "Controlled Surface Use" stipulations apply. Under "Controlled Surface Use" (CSU) for roads, pads and other kinds of soil disturbance (soil compaction and displacement), damage can only be mitigated, not avoided.

Direct and Indirect Effects

At this site, only 0.3 miles of road would have to be built from the existing road to access the site. This would equate to about 1.3 acres of road-disturbed soil. Given the relatively gentle gradients on this site, the probability that soil erosion rates would be much higher than the background rate is very low. Slope delivery ratios are low from the land types in this area, on the order of 0.10. They are not highly dissected and have a low degree of microtopography. Therefore, off-site effects from eroded soil would not be expected to be measurable. These off-site effects include covering downslope areas with sediment and sediment delivery to a stream.

The well site itself is on gentle grade, occupying about five acres. Although the site would be mostly uniform bare ground, there would be slope breaks created by structures and equipment. Also, a berm would be constructed around the pad to contain potential spills, which would also catch eroded soil. Reclamation would replace topsoil removed from the pad. Therefore, the pad would not be expected to result in long-term damage (beyond the life of the development) because of soil erosion.

This well would be a dry hole according to the "reasonably foreseeable development" scenario. The road would have no benefit after the well was drilled and abandoned. From a soils standpoint, this road should have to be obliterated after it was no longer needed for oil/gas exploration. After this mitigation was carried out, the damage from soil displacement and compaction would be negligible. Although the subsoil under the road and pad would be compacted, upon reclamation with the good topsoil found in the area, there should be no long-term damage to other surface resources such as vegetation (see 'cumulative effects', below). Because the area damaged for this well by a road and pad would only be about six acres, no measurable effects on water infiltration and runoff from subsoil compaction would be expected. Soil displacement would likewise have no damaging effects beyond the life of the development, because the road obliteration and pad reclamation would be expected to restore the ability of the soil to perform its ecological function.

The probability of contaminating large amounts of soil by an accidental spill would be very small. This is because: the slopes on these land types are relatively gentle (average about 8%); the berm around the drill pad should contain a spill on these grades; the medium-grained soils here would absorb small spills at relatively shallow depths and limited areas; the soils are deep enough and have high enough surface area, given their particle size classes, to contain most spills without spreading over a large area; because this well would not be developed, large amounts of fluids would not be stored on the site; and because the grades are gentle, reserve pits built on the site would be relatively stable.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. Roads 290, 292, and 9676 all traverse near the site. While these roads take many acres out of the natural condition, they are not serious erosion problems; the grades are gentle and they are on flat ground. The oil and gas exploration-caused disturbance would be obliterated or restored after the well-drilling was finished.

Because the soils are fine-textured with smectite mineralogy, they are more susceptible to compactive forces. Therefore, the drill site and access road would need to be deep-ripped as part of the restoration process following topsoil placement. The topsoil would need to be separated from subsoil as it was stripped. Topsoil would need to be windrowed in piles no more than four feet high to maintain its biological viability. Research and experience in mine reclamation has shown that topsoil piled in very high piles loses some of its biological diversity. This in turn lowers the quality of the topsoil for site restoration. When these rehabilitation practices were correctly applied, the cumulative effect on soil development and processes from soil loss, compaction or displacement would not be expected to damage ecosystem function either in the drill- site area or at the landscape level. For this assessment to apply, all exploration work and vehicle use would have to be restricted to the well site pad and roads.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

2. Ledford Well Site

This site has approximately one-quarter of the drill pad on mass-wasted (slumping) soil. "No Surface Occupancy" applies to this portion of the site. All of the site and road have sensitive soils which are relatively easily compacted. "Controlled Surface Use" applies to the site and road because of this condition.

Direct and Indirect Effects

One-half mile of road would be built to access the well site. This would be about 2.2 acres of soil disturbance, in addition to about 5 acres of disturbance for the well site drill pad. Because of slopes that get up to about 20%, it is estimated soil erosion by surface wash would be greater than natural rates even with the normal mitigation measures. These mitigation measures are water-barring the road according to standard soil, slope and precipitation levels; road obliteration following completion of the exploration; and restoration of the well site. Slope delivery ratios are low to moderate except for the southern portion of the well site area, where they are high. One could expect about 30% of the soil eroded from the site to move to the unnamed first order fork of Ledford Creek nearest the well site. Mitigation is estimated to be about 80% effective, so about 6% of the total soil eroded from the development area could be expected to end up in the drainage. The importance of this indirect off-site effect depends on the existing situation in this fork. Consult the hydrology and fisheries effects section for any discussion of sediment in this drainage. The direct consequences of the expected level of soil erosion on the site would be permanent, but the loss of soil productivity, small.

The southeast corner of the well site has No Surface Occupancy stipulations as a condition of the lease, so no effects would be expected here. The land type (nivational basin) above the current mass-wasting area is not known to be unstable in its undisturbed condition. In practice, this land type has been typically avoided in other forest developments, such as timber sale roads. The soils are often poorly-drained because of clay loam subsoils, and these land types have potential for slope failure if disturbed by road cuts, particularly where slopes are greater than about 35%. The slopes on this well site are about 20%, so the area is under Standard Lease Terms, where the Forest Service can ask to have the drill site moved up to 200 meters. Within this distance, any potential slope instability problems would be expected to be avoided.

Because this well is a dry hole in the reasonably foreseeable development scenario, the road would be obliterated following completion of the drilling. Although the subgrade would remain compacted, pulling the fill and resurfacing with topsoil should allow adequate restoration of the soil and vegetation resources. Because the area damaged for this well by a road and pad would only be about 7 acres, no measurable effects on water infiltration and runoff from subsoil compaction would be expected for the site. Soil displacement would likewise have no damaging effects on the site beyond the life of the development, because the road obliteration and pad reclamation would be expected to restore the ability of the soil to perform its ecological function.

The probability of contaminating large amounts of soil by an accidental spill is considered unlikely, because the slopes are not steep (the steeper slopes of the well site are under "No Surface Occupancy"); the berm built for the reserve pit and well pad should contain a spill on these grades; the soils have large surface area because of their fine-medium grained particle sizes to absorb smaller spills at a relatively shallow depth; this well would not be a developed, producing well, so there would be no production storage on site. Because the grades are moderate, reserve pits built on the site would be stable. The reserve pit would not be allowed to be built in the areas of poorly-drained soils, but in the stable land type on the southwest third of the well site.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. The Ledford Creek Road and Forest Service No. 57 traverse near the site. The Centennial-Divide Road # 100 will be upgraded in the next few years. While these roads take many acres out of the natural condition, they are not serious erosion problems, with the exception of a few steep stretches of the Ledford Road. These areas will be reconstructed. The oil and gas exploration-caused disturbance would be obliterated or restored after the well-drilling was finished.

The soils are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

3. Cliff Lake Well Site

Under Alternative 1, this well site and 0.7 acres of new road, are all under "Standard Lease Terms" for slopes and mass wasting, existing or potential. "Controlled Surface Use" applies for sensitive soils, so that mitigation for soil compaction can be applied. This mitigation, as noted elsewhere, includes reclamation standards to offset soil compaction and displacement, and requires that all vehicles and other equipment stay on the road or drill pad.

Direct and Indirect Effects

0.7 miles of new road, 3.0 acres, plus the drill pad of approximately 5 acres would be disturbed by exploration in this area. The grades and slopes are relatively gentle, ranging from about 7 to 15%. Given this, the likelihood of a storm event causing a large amount of erosion would be small. Slope delivery ratios are low from the land types in this area, on the order of 0.10. They are not highly dissected and have a low degree of microtopography. Therefore, off-site effects from eroded soil would not be expected to be measurable. These off-site effects include covering downslope areas with sediment and sediment delivery to a stream.

This well would be a dry hole as per the "reasonably foreseeable development". Therefore, the road should be obliterated following completion of the well. When this mitigation has been carried out, damage from soil displacement and compaction should be negligible. Although the subsoil under the road and pad would be compacted, upon reclamation with the good topsoil found in the area, there should be no long-term damage to other surface resources. Because the area damaged for this well by a road and pad would be about 8 acres, no measurable effects on infiltration and runoff from subsoil compaction would be expected.

Like the other well sites with low gradient slopes and medium-fine textures, the probability of contaminating large areas of soil from an accidental spill would be remote. The following repeats the reasoning used to determine that these dry hole exploratory wells on these land types and soils would pose little direct threat to the soil resource and little indirect threat to vegetation, groundwater, and other resources: slopes are gentle (7-15%); a berm is constructed around the pad or around the storage area as a precautionary measure against spills; since this is not a development well, only a reserve pit is needed, and only for a short while. On these wells, it is likely the only storage outside the drilling mud would be for fuel for the generators; the medium- to fine-grained soils would be expected to absorb relatively small spills at shallow depths and small areas; the soils here are deep enough and have enough surface area to contain most spills without spreading over large areas; because the grades are gentle and the well would be short-lived, storage pits built on the site would be relatively stable.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. The Cliff Lake Research Natural Area boundary is just a few hundred feet from the well site affected area. Road 72415 is located near the site. While these roads take many acres out of the natural condition, they are not serious erosion problems; the grades are gentle and they are on flat ground. The oil and gas road would be obliterated and the pad restored after the well-drilling was finished.

The soils are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

The Cliff Lake Research Natural Area (RNA) boundary is a few hundred feet north of this well site. The prevailing winds would carry any fugitive dust and gasses generally toward the RNA. This presents some concern, for example, if hydrogen sulfide gas escaped from the well, it would move toward the RNA. Because this is not a producing hole in the "reasonably foreseeable development", the risk to the integrity of the RNA is not considered to be great. Slopes are generally to the southeast, so any potential erosion or chemical spill accidents should not affect any RNA values.

4. West Fork Well Sites

Three wells, all in adjacent sections, are included in these effects. These closely spaced wells demonstrate the effects from a small field development. Their life expectancy is estimated at about 20 years. Under Alternative 1, "No Surface Occupancy" only applies to drill pads, not to roads or other linear features.

Direct and Indirect Effects

These wells are identified as the West Fork north, center, and south well sites. Access to the north well would require 1.6 miles of new road, or 6.9 acres disturbed. The center well would require 0.9 miles of road or 3.9 acres disturbed. The south well would require 1.2 miles of road or 5.2 acres disturbed. The associated drill pads would disturb 5 acres each.

The road to the north well would require two creek crossings, and would cut some side slopes as steep as 40%. The slopes range from about 20 to 40% across this particular land type. Soil erosion hazard is moderately high, road grades are up to 10%, and there would be some high cuts and fills due to the steepness of the slopes, so erosion would be a problem. Sediment delivery ratios are relatively high around this well, on the order of 0.25. Mitigation effectiveness would not be much more than 50%, so soil erosion from this well site and road would be an important consequence both directly and indirectly, on and off-site.

The land types affected by the north well site and road are not known to be inherently unstable in an undisturbed condition. However, some small cutslope failures could be expected in these soils when road cuts were built. If this was not anticipated in road location and design, road failure could become a major and ongoing problem.

The center well, in contrast, would have few of the problems of the north well. This land type has slopes that range from 5-20%, and the drill pad would be on a 5% slope. Similarly, the access road affects slopes that are less than 20%. Soils here are deep and well-drained, presenting much less of a risk of slope failure. Although the soils here are highly erodible under concentrated runoff, the gentle grades and slopes make it easy to locate, design, and control soil erosion hazards. Slope delivery ratio here is low, so indirect and off-site effects should also be low.

The south well drill pad would be intermediate in hazards and effects compared to the other two. Slopes are about 25%, so the pad would require a moderately high cutslope. The soils are not known to be a problem for mass-wasting if undisturbed, but with a high cut, one could expect to have some shallow sloughing. The access road would present some problems because it transects a mass-wasted land type. If a road cut caused further slope failure, it could present an obstacle to restoration, which would represent a long-term impact to the soil resource and to Fox Creek, about a quarter mile away.

The potential for contamination from a chemical spill would be relatively high for the north well, at least compared to some of the dry-hole wells. This is because the pad would be built on a steep slope (up to 40%), so the risk of pit failure would be comparatively higher than for a gentler slope. Standard construction practices call for pits to be constructed in cut material to reduce the risk of a breach or spill. If it still happened, however, the steeper slopes off the pit would allow a spill to travel farther and the soils are not always well-drained in this land type, so even a relatively small spill would not be readily absorbed by the soil in a small area and shallow depth. These soils do have a high capacity for absorption, however, if the pores are not filled with water. This well would be an oil producing well for about 20 years, so there would be more fluids available for an accident for a long time. A relatively small spill (about a hundred gallons) could cause long-term damage to the soil resource, and possibly to surface and ground water. Salt water and brines would be the most damaging, followed by oil, fuel, and drilling mud additives.

For the center well, risk of contamination would be much lower, but still greater than for a dry-hole well. Slopes and soils are favorable for lessening the extent of a spill. A long-term producing well would produce some hazard though, even under these favorable conditions. Salt water, brines and stored oil would be the most likely fluid spilled to cause damage.

The south well would present about the same hazards as the north well for a spill, except the soils would be better suited to absorb fluids at a shallow depth and small area.

All three well sites have sensitive soils from compaction, especially the north well. Soil displacement would be a problem at the south well, where there are areas of shallow, flaggy loams. The effects are considered long term, since these wells would be around for about 20 years. Since these roads would not be obliterated and the pad would not be restored for 20 years, the compaction and displacement would eliminate the biogeochemical functions of the soil resource on these acres for the life of the well. Physical functions, like soil moisture transmission and storage, would remain highly altered on these disturbed acres. Water infiltration and storage would be affected downslope on the rest of the land types that contain developments. Because the developed areas would be small, no notable effects would be expected in structure or function of soil and vegetative resources in these downslope areas.

Cumulative Effects

Since the mitigation techniques used for the dry hole wells cannot be applied here, there would be some cumulative effects. The other uses and development around this well site include livestock grazing and dispersed recreation. Roads 290, 347, traverse near the sites; others exist within several miles. There are no other developments (new roads, timber sales, etc.) foreseeable in the area over the next 20 years. While these roads take many acres out of the natural condition, they are not serious erosion problems. The main road (290) was reconstructed and surfaced with gravel in 1986.

Because the soils are fine-textured with smectite mineralogy, they are more susceptible to compactive forces. Due to the compaction and displacement at these well sites, soil development would be stopped. Normal weathering processes, organic matter incorporation, and geochemical cycling would not function and soil productivity would be eliminated. All operations and vehicle use would have to stay on the roads and drill pad for these estimates to be valid.

Plants would be eliminated from the roads and drill site for the duration of the wells, about 25 years. During this time, weedy and introduced species could take over road and pad cuts and fills. To prevent affecting the native plant communities surrounding the sites, these disturbed areas would have to be treated with rehabilitation measures. Seedbed preparation, seeding, mulching and protection of these places would have to be maintained to prevent serious effects in the surrounding landscape. Recommended restoration guidelines for vegetation are detailed under "Sites Which are Projected to be Dry Holes" at the beginning of the Soils section.

This long-term, active disturbance could promote a serious loss of biological diversity if protective measures were not implemented. If protection measures were taken, no large effects on the soil and plant resources would be expected. If alien species were introduced and allowed to spread onto the landscape, permanent loss of native diversity would result. This would reduce soil productivity, produce a permanent disclimax plant community, and could eliminate rare plant elements in the landscape. These effects would threaten the multiple uses of the forest by reduced wildlife and livestock forage, and reduced recreational opportunities.

Noxious weeds would have to be controlled until the temporary rehabilitation measures were self sustaining. Because achieving a sustaining community without weeds and exotics might not happen, continual maintenance would have to be done. This would include not just weed control, but also reseeding, transplanting, mulching, and protective measures to control the kind of disturbance community that existed on these long-term developments. Without protective maintenance, the damage done to soil and plant resources on the landscape might be permanent.

5. Antone Well Site

In Alternative 1, this site fell in an area of No Surface Occupancy. There would be no surface disturbance, therefore, no change in the existing condition.

LIMA PLANNING UNIT

6. Sourdough Well Site

This dry hole would require 1.9 miles of new road, or 8.2 acres of soil disturbance, plus the drill pad of approximately 5 acres. The pad might require more than five acres, depending on where it was situated within the well site area. The eastern third of the site is steep (50% slopes) and would require a large cut if located here. Standard Term stipulations apply except for areas of sensitive soils, where "Controlled Surface Use" applies.

Direct and Indirect Effects

The road to this site would be on gentle grade and stable soils. The road would be obliterated following exploration, and soil and vegetation would be restored. No effects would be expected from accelerated erosion because of the road. Slope delivery ratios are low from the land type that comprises most of the well site area and all of the road. Off-site effects from eroded soil would not be expected to be measurable, or would be low. These off-site effects include covering downslope areas with sediment and sediment delivery to the unnamed ephemeral fork of Sourdough Creek.

About a third of the well site area is within steep land types (up to 50%). Even though this would be a dry hole with a very short life, there would be a good chance of producing considerable erosion from the cut and fill areas of the pad if it was constructed on these steeper land types. Erosion control measures such as a cut slope interception ditch would be expected to be about 50% effective. The slope delivery ratios on this steeper land type are about 0.20, so about 10% of the initial eroded soil would be expected to be carried off-site to the head of this first order drainage.

It is assumed the access road would be obliterated following abandonment of the well. When this was done, the on-site damage from soil compaction and displacement would be negligible. Although the subsoil under the road and pad would be compacted, upon reclamation with the topsoil available on the well site, there should be no long term damage to other surface resources. Because the area affected by this development would be only about 15 acres, no measurable effects on water infiltration and runoff from subsoil compaction would be expected. Soil displacement would likewise have no damaging effects beyond the life of the exploration, because road obliteration and pad reclamation would be expected to restore most of the original productivity of the disturbed soils.

The probability of contaminating large amounts of soil by an accidental spill would be small to moderate, depending on where in the well site area the pad was actually located. Because a large cut and fill situation would be encountered if the pad were located on the eastern third of the area, it could be assumed the flatter section would be used for the pad, but this is not certain. On the steeper part, a moderate risk would be expected due to the comparatively higher pit failure risk in spite of its construction in cut material; the likelihood of a spill moving farther due to the steeper slopes. If the pad were on the flatter portion, risk would be low because of the relative stability of the pit and the low slope angles on fill which would allow absorption. The absorption capacity of the soils across the well site are about equal.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. Road 956.2 traverses near the site. There are no plans for road construction or upgrading in the foreseeable future. While this road takes many acres out of the natural condition, it is not a serious erosion problem. The grades are gentle and the soils usually have some gravel and rock in the upper layers. The surface fines eroded away many years ago, but the existing road surface is largely stable. The oil and gas exploration-caused disturbance would be obliterated or restored after the well drilling was finished.

The soils are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

7. Lima Peaks Well Site

This site would require 4.25 miles of new access road. With the drill pad, this would disturb at least 23.3 acres. 0.75 miles (3.2 acres) of the road are on National Forest, the rest on BLM and state. None of the road would cross mass-wasted land types. Standard Term stipulations apply except for land types with sensitive soils for compaction or displacement, where "Controlled Surface Use" stipulations apply.

Direct and Indirect Effects

The road grade and sideslopes the access road crosses would pose the risk of accelerated erosion even for this short-term, dry hole exploration. The drill pad would also pose a risk for soil erosion. These risks would not be completely eliminated by application of erosion control treatments. On these soils and land types, mitigation measures for this development would be expected to be no more than about 60% effective. Slope delivery ratios on these land types are about 0.25, which is moderately high. Of the eroded soil that left the site, approximately 15% would be moved downslope and would eventually reach Dutch Hollow or an unnamed tributary of Alder Creek.

This is a high elevation site, and about half of the well site is on a strongly frost-churned/patterned ground land type that has very shallow soil and is excessively well-drained. This makes this half susceptible to soil displacement. There is little topsoil available to use in restoration. Mixing of subsurface soil would not provide reclamation material as good as at other sites which have more soil development. It would be expected that reclamation of the portions of the road and drill pad located on this land type would not restore most of the original character and productivity of the predisturbance site.

The other side of the ridge containing the rest of the well site and road has different aspect, climate, and soils. Here, the soils are much deeper (up to 40 in.), and though they have 35% coarse fragments, they have much more fines than the shallow, coarse soils on the other side of the ridge. They also have some clay loams in the subsurface and are readily compacted. Because the soil is much deeper here and more developed, restoration should be more successful than on the other side, so no long-term effects would be anticipated for disturbance on the east side of the ridge.

The potential for extensive contamination from a chemical or fuel spill is relatively high, for a dry hole. While not having the potential of some of the developed wells, the steep ridgetop location of the drill site alone would increase the chances for an otherwise innocuous fuel spill to become a problem difficult to remedy. If chemicals or fuel spilled on the west side slope, the very shallow, stony, and excessively-drained soils would allow a large area to be contaminated. It would be difficult to remove because of the slope and larger rock.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. This is an unroaded area, with no construction planned in the foreseeable future. The access road would take many acres out of the natural condition, and would be somewhat of an erosion problem for several years, even with reclamation. The grades run up to 12% and the sideslopes up to 60%.

Soils on the east side of the ridge are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site.

Similar restoration measures need to be done on the west side of the ridge. They would not be as effective, however, because there is little soil to work with there. Soil disturbance on the west side of the ridge would result in some permanent impairment to soil productivity, plant succession, and diversity.

If the recommended guidelines for soil and vegetation restoration were applied, and successful, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale. It is expected that restoration would not be wholly successful on the west side of the well site, so we expect this side to retain much of a disturbance character.

8. Sawmill Well Sites

There are three wells involved in the Sawmill Creek area, and they are seen in the "reasonably foreseeable development" scenario as natural gas producing wells with a production life of about 40 years. Under Alternative 1, "No Surface Occupancy applies only to drill pads, not to roads.

Direct and Indirect Effects

West Well Site

At the western-most well site, most of the well site and part of the access road are in mass-wasted land types. More than 3/4 of the well site area is "No Surface Occupancy". On the remainder, the slopes range from about 42% to 52%. A drill pad would require quite high cut and fill slopes, requiring more than five acres of soil disturbance. Therefore, there would not be enough area to place a drill pad on the site. For the purposes of this analysis, it is assumed the western well site would not be used as proposed. The road is considered, since a part or all of it would be used if the site were moved anywhere in the immediate vicinity. The road would cover 3.1 miles and would disturb 13.3 acres. No disturbance is assumed for the drill pad since 80% of the well site is under No Surface Occupancy.

Almost all but a few hundred yards of the road traverses mass-wasted land types. While there may be a way to locate a road through these to avoid the least stable areas, it is expected road cuts would cause slope failures in these types. These slumps could cause long term movement and so would not be restorable, creating a long term or permanent loss of the current level of soil development and productivity. Some of the destabilized soil could reach Sawmill and Deep Creeks, causing long-term sediment problems in these streams.

Central Well Site

The Sawmill central well would be on a relatively flat slope (about 20%), with soils not known to be unstable in an undisturbed condition. Given this would be a long-term development well, soil erosion would be a problem not wholly contained. Mitigation could be expected to be about 50% effective. Slope delivery ratios are about 0.20-0.25, so 10 to 12.5% could be expected to move downslope and eventually reach

Sawmill or Deep Creeks. The road would disturb 1.7 acres and the pad would disturb 5 acres.

The soils for this well and road are sensitive to compactive forces, so compaction would be a long-term effect. Since the roads would not be obliterated, and the pad would not be restored, the compaction and displacement would eliminate the biogeochemical functions of the soil resource on these acres. Physical functions, like soil moisture transmission and storage, would remain highly altered on these disturbed acres. Water infiltration and storage would be affected downslope on the rest of the land types containing developments. Because the developments comprise a small area, however, no notable effects would be expected in structure or function of soil and vegetative resources in these downslope areas.

South Well Site

The southern well would be on moderately steep land types with discontinuous mass-wasting. The center of the well site intersects this land type, while the other sides are on normally stable land types. About a half mile of road also crosses this secondarily mass-wasted land type. Although a portion of the well site would fall in NSO, there would be enough room to place the pad. The road would disturb 6.5 acres and the pad would disturb 5 acres.

Even though the road crosses NSO, Alternative 1 would allow it to be built. A road cut would be expected to cause slope failure, at least of a discontinuous nature, along the length of this impacted slope. This would create permanent damage to the soils and land form because it would not likely be restorable. Long term soil productivity would be greatly reduced, slope hydrology would be altered, and plant biodiversity would be permanently decreased due to exposed soil available for colonization by introduced and weed species.

The access road would cross this same land, but also would cross a terrace and the stream bottom of Sawmill Creek. The road grades would be moderately steep (up to 8%), and cross slopes of up to 40%. Under these conditions, and because these developments would remain for about 40 years, soil erosion would be a serious consequence. Mitigation levels could be expected to be no more than 50% effective. Slope delivery ratios for these land types are about 0.25, so 12.5% of soil originally eroded from the road and pad, cuts and fills, would move off-site.

Most of the drill pad and the access road for the southern well would be on sensitive soils for compaction. In these soils, the particle size classes present produce a soil texture (silty clay) relatively low in large pores and higher in small pores. The larger pores that are present, once compressed, take a long time to recover. Recovery usually requires biological and geochemical mediation.

The development wells are considered permanent effects for all practical purposes because they have such a long life. Soil compaction would also influence some physical processes off-site, particularly soil moisture transmission and storage. The area damaged, however, would be a relatively small percentage of the watershed, so it would not be expected to have noticeable effects on soil resources and vegetation off-site.

The potential for contaminating a large area and depth of soil on these well sites is relatively high. The west site has quite steep slopes as noted earlier, is contained partly within a mass-wasted land type, and has soils that would not absorb a large amount of fluids from a spill. If a moderate to large accident did occur, like the failure of a pit containing salt water or brines, a large area would be sterilized and off-site damage to stream water would also be likely. In the discussion above it was determined that the west well site could not be used due to the lack of area outside of "No Surface Occupancy" where a well site could be located. The central well site would pose much less risk because it has more favorable slopes and soils. The south well site has many of the hazards and risks of the west site, but has soils that would absorb a considerably larger amount than the west well. Because these would be long-lived production wells, the potential for a spill is greater and any moderate-sized spill could have large consequences and be difficult to completely restore.

Cumulative Effects

The other uses and development around the well sites include livestock grazing and dispersed recreation. Roads 1013, 1080, and low-standard, non-maintained roads 70117, 70083, 70112, 70084, and 70109 all traverse near the site. Beginning in about 1998, several of these Sawmill Creek roads are proposed to be reconstructed and upgraded. These roads take many acres out of the natural condition, and some are minor to moderate erosion problems. This is a fair amount of roading for an area this size. The oil and gas exploration-caused disturbance would not be obliterated or restored for the life of the wells, approximately 40 years, since these would be production wells. With this amount of roads, potential off-road traffic, and livestock, a cumulative effect on the soil resource would be anticipated. Because the soils are sensitive to mass-wasting and compactive forces, these land uses and developments would produce and maintain soil conditions over a sizeable area that would be well outside the range of natural variation in terms of soil development and productivity.

The effects of the production wells and their access roads on vegetation would be the same as those described for the West Fork well sites.

9. East Creek Well Site

In Alternative 1, this site fell in an area of No Surface Occupancy. There would be no surface disturbance, therefore, no change in the existing condition.

PIONEER PLANNING UNIT

10. Glendale Well Site

This would be an exploration dry hole with the drill site area and access road located on land types with stable soils, with the exception of the extreme northwest corner of the well site. This portion is No Surface Occupancy due to unstable slopes. "Controlled Surface Use" applies on sensitive soils for compaction or displacement. Standard Term lease stipulations apply everywhere else. For soil resources, there would be no practical difference between Controlled Surface Use and Standard Term stipulations, assuming all operations and vehicle traffic stayed on the drill pad and the roads.

Direct and Indirect Effects

Because drill pad construction is prohibited within areas of No Surface Occupancy, the following effects would not apply to the extreme northwest corner of the well site.

This well would require 1.25 miles of access road, or 5.4 acres. Adding that to the 5 acres needed for a drill pad yields 10.4 acres total soil disturbance. Most of the well site area has about 15% slope; the northern 1/5 or so has slopes of up to 40%. It is assumed the drill pad would tend toward the lesser slopes, and soil erosion control would then be about 60% effective for these soils and slope conditions. Given this and the short-term life of this exploration, soil erosion from the drill pad and its cut and fill slopes would not be expected to cause notable damage.

The road would cut across some sideslopes of up to 40% with grades of 8%. In these soils, this would be an erosion problem if this were a development well, or if the road were very long. Erosion control mitigation would only be about 40 or 50% effective. Since this is an exploration well in the "reasonably foreseeable development", the impacts would be brief, perhaps for 3-10 months. Also, this is a low elevation site in a low snow accumulation and precipitation zone (20"). Under these circumstances, it would be expected that soil erosion would be a minor damaging agent.

There would be no stream crossings except for an unnamed intermittent tributary of Canyon Creek. Slope delivery ratios are approximately 0.30 to 0.35 for the land types the road crosses. In other words, these slopes are effective transporters of eroded soil to the valley bottoms. The only reason off-site erosion effects are not considered seriously damaging, is because this is a short road, in place for a short, time and in a low precipitation zone.

The road would be obliterated and the pad restored following the completion of the well. When this was done, the effects from soil displacement and compaction would be negligible. Although the subsoil under the road and pad would be compacted, upon reclamation with the adequate topsoil found in these land types, there should be no long-term damage to other surface resources. Because the area damaged by this development would be only about 10 acres, no measurable effect on water infiltration and runoff from subsoil compaction would be expected. Soil displacement would have some lasting effect on the slopes where the road crossed, because the shallow topsoil available would not be enough to completely restore productivity.

The potential for contaminating a large area of soil from this well site from an accidental spill is small. The slopes are low to moderately steep (15-40%) and the drill pad would likely go toward the lesser slope portion of the well site. The pit would be in a stable location in this case and the fill slopes would not be steep. The berm around the drill site and/or fuel storage area should contain a small spill. The glaciated slope downhill from the well site has a complex of soils, but generally has the depth and particle size-surface area to absorb a small spill, 100 gallons of diesel fuel for example, within a small area and depth. Since this would be a dry hole well, there would not be stored production for any extended periods and there is not little, if any, probability of having salt water or brines on the well site for extended periods.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. Roads 7424, 187, and a few non-maintained jeep trails traverse near the site. Restoration of the Canyon Creek charcoal kilns is the only other development or improvement foreseen for the next five years. While the existing roads take many acres out of the natural condition, they are not serious erosion problems. The grades are gentle and the slopes are flat, since the main existing road is in the valley bottom. The oil and gas exploration-caused disturbance would be obliterated or restored after the well-drilling was finished.

Soils are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

FOREST-WIDE CUMULATIVE EFFECTS OF ALTERNATIVE 1

This discussion deals with effects on the soil resources on a forest-wide scale. The added effects of all of the well site developments are considered. The effects of accelerated soil erosion, displacement, compaction, and contamination are evaluated, similar to the descriptions of effects for the hypothetical well sites.

No damage to riparian/wetland soils and vegetation is expected. A buffer of 500 feet for either side of riparian and wetland areas is part of Alternative 1. In addition, under Standard Terms, the forest can have a well site or road moved up to 200 meters. These protected zones are expected to be sufficient to protect soils, stream banks, and vegetation from any damage as per the reasonably foreseeable development scenario. An exception would be road crossings, where soils and vegetation would be permanently affected after roads were reclaimed, because restoration would not likely return crossings to their predisturbance condition. Roads to two of the 14 RFD wells would cross third or fourth order streams (Sawmill south and Westfork north). These two crossings would cause about two thousand square feet of disturbance. This amount is not expected to be a measurable resource impact on a forest-wide scale.

Each of the RFD sites has sensitive soils comprising the well site, access roads, or both. The Ledford, West Fork, Sawmill, East Fork, and Glendale wells have existing soil mass-wasting on portions of the access roads, well sites or both. As described in the cumulative effects for the individual well sites, the most damage would be caused by the roads and pads of the producing wells, because these sites would be affected over the long term.

The existing situation includes effects from livestock grazing and other roads. Because grazing and road use cause annual effects on soils, the erosion, compaction, displacement, and any chemical contamination from oil and gas development would be additive to the existing condition.

Aggressive mitigation could be needed because soil has been compacted over much of the forest which is grassland dominated. More than a century of livestock use, which was often very heavy in the past, mining, logging, recreational traffic, and continued grazing have had their effect. It takes decades to ameliorate severe soil compaction, and in the face of continuing uses and developments, compaction can be an insidious, cumulative effect on the soil resource across the landscape.

The effects of developing all 14 RFD wells, added to all past, present, and reasonably foreseeable activities across the forest are described in Alternative 2, Forest-wide Cumulative Effects. Alternative 1 differs from Alternative 2 by buffering streams, lakes, roads, and trails with NSO; requiring NSO instead of CSU on slopes over 65%, areas of mass failure, and slopes prone to failure over 35%; and in requiring CSU instead of Standard Terms on soils sensitive to compaction.

For soils, there is no practical difference in effects between Standard Terms and Controlled Surface Use. This means there would be no difference in effects on soils sensitive to compaction between Alternatives 1 and 2. Because both alternatives lease slopes from 30-65% with Standard Terms, effects on these areas would also be the same.

Although the NSO stipulation required in Alternative 1 would protect the unstable soils from well pad development, as NSO is defined for this alternative it would not prohibit road construction. Because roads were a large part of the acres disturbed, the effects of Alternative 1 would be the same in kind as those described for Alternative 2, but slightly less in degree. Because of the greater amount of NSO stipulated in Alternative 1, two well sites would not be drilled. This also would reduce the overall effects of Alternative 1 compared to those described for development of all of the RFD wells. Alternative 1 would disturb 121 acres.

Off-site effects from eroded soil would not be measurable from 4 of the 12 hypothetical well sites analyzed. They would be low on 2 sites, medium on 4 sites, and high on 2 sites. Sites producing the most off-site effects were steep, prone to mass wasting, or production sites. Forest-wide, we could expect oil and gas activities carried out under the terms and stipulations of Alternative 1 to produce high levels of off-site sedimentation in areas where roads were allowed to be built in mass-wasted soils, on steep slopes, and on production sites where cuts would be exposed for 20 to 40 years.

Long-term effects from soil compaction would be found on the production sites until they were reclaimed. On the oil field, 31 acres would be compacted for 20 years. On the gas field, 36 acres would be compacted for 40 years. On the exploration sites, the subsoil would remain compacted after reclamation, but there would be no long-term damage to surface resources. Forest-wide, we could expect oil and gas activities carried out under the terms and stipulations of Alternative 1 to cause soil compaction for 20 to 40 years on just 77 of the forest's 2,000,000+ acres.

The chance of contaminating a large area of soil would be small on half of the sites drilled, moderate on a quarter of the sites, and high on a quarter of the sites. Sites with the highest chance of contamination were production sites or were steep with shallow soils. Forest-wide, we could expect oil and gas activities carried out under the terms and stipulations of Alternative 1 to carry a high chance of limited, local soil contamination on production sites.

The discussion for Alternative 2 concluded oil and gas exploration and development would only damage soil and related ecosystem processes to a small degree at the forest-wide scale. If recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at the well site area or landscape scale for any of the 8 exploration well sites. Therefore, there would be no disruption of ecosystem integrity at the forest-wide scale due to exploration wells. Since Alternative 1 only drills 6 of the 8 exploration wells, the forest-wide effects would be slightly less in degree than those described for Alternative 2.

On the soil disturbed by production sites and their access roads, soils would be affected for the life of the wells. For our hypothetical oil field, 31 acres would be out of production for 20 years. For our hypothetical gas field, 36 acres would be out of production for 40 years. If recommended mitigation was followed to prevent establishment of noxious weeds and introduced species and to stabilize cut and fill slopes, no large effects on the soil and plant resources would be expected.

ALTERNATIVE 2

Following the analysis of Alternative 1, it became evident there would be relatively few changes in effects between most of the alternatives. Alternative 3, no lease, being the exception. Under Alternative 2, slopes over 65%, areas of mass failure, and areas prone to failure on slopes over 35% are stipulated Controlled Surface Use. Areas sensitive to soil compaction and stable slopes between 30 and 65% are leased with Standard Terms. For soils, there would be no practical difference between Standard Terms and Controlled Surface Use, assuming that all operations and vehicle traffic were on the roads and drill pad.

GRAVELLY PLANNING UNIT

1. Crockett Lake Well Site

Direct and Indirect Effects

The road or pad would not be located on any areas of mass wasting or slopes over 65%. Sensitive soils effects would be mitigated during restoration. Therefore, the effects of this alternative would be similar to those described under Alternative 1.

Cumulative Effects

Mitigation and restoration standards are the same for Standard Term and Controlled Surface Use stipulations. So cumulative effects would be the same for this alternative as for Alternative 1.

2. Ledford Well Site

Direct and Indirect Effects

About ¼ of the hypothetical well site lies on a land type with mass-wasted soils. Under Controlled Surface Use stipulations, this portion could be developed for a drill pad. Excavating these slopes for a drill pad could produce severe slope stability problems which could not be restored. Normal soil development would be arrested and productivity would be reduced upon the initiation of accelerated mass-wasting. This result is due not only to the direct erosion, but also to the displacement that exposes undeveloped soil parent material. One could expect about 30% of this soil to move off-site and reach the unnamed fork of Ledford Creek over time.

All other effects are similar to those described under Alternative 1.

Cumulative Effects

The effects here are similar to those described for Alternative 1, except for the portions of the well site where mass-wasting occurs. Under Alternative 2, this could be developed for a drill pad. As noted above, if the mass-wasting portion of the site were developed, the soil could not be restored to its original processes and productivity. This would be considered a cumulative effect because an existing road and livestock grazing are currently impacting soil processes, productivity, and plant succession; impacts which will not change or are not restorable in the foreseeable future. On a site and area basis, these effects are important. On a landscape scale such as the Snowcrest Range, these cumulative effects would not be of high consequence in the foreseeable future.

3. Cliff Lake Well Site

Direct, Indirect, and Cumulative Effects

Since there is no practical difference between Controlled Surface Use and Standard Terms relative to soils, all effects of this alternative for this site would be similar to those under Alternative 1.

4. West Fork Well Sites

Direct, Indirect, and Cumulative Effects

North, Center, and South Well Sites

The effects would be similar to those described for Alternative 1. Because roads are not included under No Surface Occupancy in mass-wasted soils in Alternative 1, they were treated as Controlled Surface Use and Standard Term cases. Alternative 2 does this by design.

5. Antone Well Site

This hypothetical dry-hole site has "Standard Term" lease stipulations except for areas of sensitive soils because of displacement. 0.2 miles of road would be built for this well, disturbing just 0.9 acres. "Controlled Surface Use" would apply to these.

Direct and Indirect Effects

This would be a dry hole well with access roads and drill pad on low angle slopes and stable soils. Given this, the probability soil erosion rates would be much higher than the background rate is low. Slope delivery ratios are low to moderate from the land types in this area. Off-site effects from eroded soil would not be expected to be measurable. These off-site effects include covering downslope areas with sediment and sediment delivery to a stream, in this case, the unnamed first order tributary of West Fork Blacktail.

The well site is also on a relatively gentle grade, less than 20%. Drill pad sites are generally uniform bare ground and smooth surface, except for the pit. They are cut to a flat slope, and surface breaks are created by equipment and structures. A berm is constructed for the pit and for fuel storage areas. So, it is unlikely that a large storm event would produce more than a minor amount of soil erosion. The stripped topsoil from the pad would be replaced following exploration as part of the restoration. Therefore, no damage from soil erosion would be expected beyond the life of the exploration (3-10 months).

It is assumed the access road would be obliterated following abandonment of the well. When this mitigation was completed, the on-site damage from soil compaction and displacement would be negligible. Although the subsoil under the road and pad would be compacted, upon reclamation with the good topsoil found in the area, there should be no long-term damage to other surface resources. Because the area damaged within this watershed would be only about six acres, no measurable effects on water infiltration and runoff from subsoil compaction would be expected. Soil displacement would likewise have no damaging effects beyond the life of the development, because the road obliteration and pad reclamation would be expected to restore most of the original productivity of the disturbed soils.

For the reasons stated for the Crockett Lake well site, the probability of contaminating large amounts of soil by an accidental spill is very small. The Antone site is slightly steeper than the Crockett Lake site, but the same rationale applies.

Cumulative Effects

The other uses and development around this well site include livestock grazing and dispersed recreation. Road 325 and some wheel tracks all traverse near the site. Other than trail reconstruction, no other developments are foreseeable. Road 325, Antone, was reconstructed and surfaced with gravel in the mid-1980's. While this road takes many acres out of the natural condition, it is not a serious erosion problem; the grades are gentle and the sideslopes are not very steep or high. The oil and gas exploration-caused disturbance would be obliterated or restored after the well-drilling was finished.

The soils are similar to those described for the Crockett Lake site. Restoration measures recommended for these soils are described in detail for that site under Alternative 1.

If the recommended guidelines for soil and vegetation restoration were applied, there would be no plant succession/soil productivity problems expected that would be serious enough to disrupt ecosystem integrity at either the well site area, or landscape scale.

LIMA PLANNING UNIT

6. Sourdough Well Site

Direct, Indirect, and Cumulative Effects

This hypothetical well site has no steep slopes or soil mass-wasting limitations and so was described as Standard Term and Controlled Surface Use under Alternative 1. Alternative 2 also has the Controlled Surface Use stipulations. Therefore, the effects would be the same as those described under Alternative 1.

7. Lima Peaks Well Site

Direct, Indirect, and Cumulative Effects

Because the stipulations applied to this hypothetical well site and access road would be the same for Alternative 2 as they were for Alternative 1, the effects would also be the same.

8. Sawmill Well Sites

Direct and Indirect Effects

The effects for these well sites would be similar to those described under Alternative 1, except for a portion of the west well site, which has mass-wasted soils, and a very small area where the slope exceeds 65%. Under Alternative 1, this was No Surface Occupancy. Here it is Controlled Surface Use. Under Alternative 2, this well site would be developed. The results of excavating on this steep slope (25-70%) on this land type are hard to predict compared to most other mass-wasted land types. The slope failures here are discontinuous without disturbance. For the purposes of this analysis, it is assumed slope failure would occur with development. Soil mass-wasting on this slope would not be restorable. Soil development, biogeochemical cycling and soil biology would be altered so that soil productivity would be reduced to below the range of variation inherent within this soil type. Soil physical processes, solute and gas diffusion and moisture storage, would be altered to the degree that on this site and downslope on the land type, normal soil development, and hydraulic properties could not function normally. This would result in a permanent decrease in productivity both on-site and immediately downslope. Slope delivery ratios for this land type are typically in the range of 0.25 -0.35, moderately high to very high. Significant damage to Deep Creek could be expected from soil mass-wasting reaching the creek.

Cumulative Effects

Again, the effects would be similar to Alternative 1, except for the effects of developing the Sawmill west drill site. Given the effects described above, plus those of the road (described for Alternative 1), and the other uses and developments existing in the area, it is expected there would be cumulative effects on the productivity and biodiversity of the area. The effect of the slumping from developing a drill pad and from building the access road would change the plant community composition and structure. These severe long-term to permanent disturbances would not allow plant community succession and development to proceed normally. The plant community would be frozen in a disturbance regime of early successional species, weedy species, and introduced exotics. These species would spread over time to the surrounding landscape, affecting other uses and values of the forest. It is expected forage production would decline for both wild and domestic animals, current level of recreational use and enjoyment would decline. Soil productivity over the landscape would then decline and rare elements (plant populations) could be eliminated from the area.

9. East Creek Well Site

This hypothetical well site would require 7.0 miles of new road for access (30.1 acres), plus about 5 acres for the drill pad. This well would be a dry hole with