Appendix C

APPENDIX C-1:

MAP 5-M: SOIL CHARACTERISTICS (11" X 17")

APPENDIX C-2:

TABLE 9-T: SOIL CHARACTERISTICS SUMMARY

APPENDIX C-3:

SOIL QUALITY INDICATORS

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APPENDIX C-1:

MAP 5-M: SOIL CHARACTERISTICS (11" X 17")]

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APPENDIX C-2:

TABLE 9-T: SOIL CHARACTERISTICS SUMMARY

Plot Number	Area Location	Allotment Name	Depth-to-Saturation	Rangeland Type	Topsoil Texture	Horizon (cm)	depth (cm)*	ground (% Area)*	Soil Surface Horizon Structure*	Soil Structure in Root Zone*
21963	Spring City	Buttermilk	150	Dry meadow	silt loam	12	4	38	medium granular	Extremely coarse platy
21964	NF Cabin Crk	Martin Basin	150	Dry meadow	silt loam	42	14	22	thin platy	Coarse angular blocky
21965	Bradshaw Crk	Bradshaw	69	Wet meadow	silt loam-sandy clay loam	100+	17	26	thin platy	Coarse angular blocky
21971	Granite Pk	Granite Pk	84	Moist meadow	silt loam-loam	100+	14	31	medium granular	Medium platy
22983	Falls Crk	Buffalo	150	Cotton-wood	sandy loam	63	8	2	fine granular	Coarse granular
22985	Granite Pk	W Side Flat Crk	49	Cotton-wood	silty clay loam	34	9	1	fine granular	Sub-angular blocky
22986	Solid Silver Crk	Granite Pk	150	Moist meadow	silt loam	50	6	1	fine granular	Granular
95800	Cabin Crk 1A	Martin Basin	39	Dry meadow	silt loam	29	13	17	fine granular	Fine sub-angular blocky
95801	Cabin Crk 1B	Martin Basin	36	Wet meadow	loam	21	13	n/a	fine granular	Coarse blocky
95802	Cabin Crk 2	Martin Basin	51	Wet meadow	loam-fine sandy loam	9	9	20	fine granular	Medium sub-angular blocky
95803	Bradshaw Field	Bradshaw	25	Wet meadow	silt loam	54	18	10	medium granular	Coarse Platy
95804	Lye Crk 2	Buttermilk	150	Dry meadow	loam	36	10	7	fine granular	Medium sub-angular blocky
95805	Lye Crk 2	Buttermilk	150	Dry meadow	loam	22	13	4	fine granular	Coarse sub-angular blocky
95806	Dutch John 1A	Bradshaw	150	Dry meadow	very fine sandy loam-loam	22	5	76	fine granular	Coarse sub-angular blocky
95807	Dutch John 1B	Bradshaw	90	Wet meadow	silt loam-loam	28	28	4	fine granular	Medium sub-angular blocky
95808	Dutch John 1C	Bradshaw	40	Wet meadow	very fine sandy loam-loam	28	28	21	medium granular	Fine sub-angular blocky
95809	Dutch John 1D	Bradshaw	60	Moist meadow	fine sandy loam-loam	16	16	1	fine granular	Fine granular
95810	Road Crk 1	Buttermilk	102	Dry meadow	silt loam	20	6	1	fine granular	Coarse sub-angular blocky
95814	Martin Crk 1	Martin Basin	34	Wet meadow	fine sandy loam-loam	6	6	23	fine granular	Medium platy
95815	Indian Crk 1	Granite Pk	76	Moist meadow	sandy loam	9	22	1	fine granular	Medium sub-angular blocky
99935	Devil's Gate 1	Indian	160	Dry meadow	loam	27	8	2	very fine platy	Medium platy
99936	Devil's Gate 2	Indian	150	Dry meadow	loam-fine sandy loam	48	5	0	coarse blocky	Medium angular blocky

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APPENDIX C-3:

SOIL QUALITY INDICATORS

Compaction

Soil compaction occurs when moist or wet soil aggregates are pressed together and the pore space between them is reduced. Pressure, weight per unit area, exerted on the soil surface by large animals, vehicles, and people can cause soil compaction. Compaction changes soil structure, reduces the size and continuity of pores, and increases soil density. In areas of rangeland, compacted soil layers are generally within six inches of the surface, although they can be as deep as two feet under excessively wet areas or heavily used roads and tracks.

Compaction reduces the capacity of the soil to hold water and the rate of water movement through soil. It limits water infiltration and causes increased runoff and, in some areas, increased erosion (Warren et al., 1986). When the amount of water that enters the soil is reduced, less water is available for plant growth and percolation to deep root zones. An increase in the amount of water near the soil surface and a decrease in the amount of water deeper in the soil may favor the shallower rooted annuals over the deeper-rooted plant species that constitute forage for livestock. Where soil density increases significantly, it limits plant growth by physically restricting root growth. Severe compaction can limit roots to the upper soil layers, effectively cutting off access to the water and nutrients stored deeper in the soil. There is a strong correlation between increased compaction versus reduced infiltration, reduced standing crop biomass, and reduced basal cover of vegetation (Weixelman, et al., 1997)

The following features may indicate a compacted soil layer (USDA, Natural Resources Conservation Service, 2001, Rangeland Sheet 4):

- Platy, blocky, dense, or massive appearance;
- Significant resistance to penetration with a shovel or metal rod;
- Restricted, flattened, turned, horizontal, or stubby plant roots.

Trampling

Trampling may occur when large animals concentrate repeatedly or in large numbers in a small area for water, shade, or other streamside attractions. Hoof impacts may destroy stream bank vegetative cover. The sharpness and the pressure load of the hooves may also cause banks to shear and to slough into the water. This sloughed off soil is eroded away by water. In addition to adding sediment to the watercourse, this may lead to channel widening or down-cutting. Channel widening and down-cutting can result in loss of riparian vegetation, shallower and warmer streams, degrading aquatic habitat, and destroying important streamside wildlife habitat.

The following features may indicate trampling in a riparian area:

- Unstable stream banks;
- Increase in width/depth ratio of stream;
- Head cutting resulting in incision;
- Embeddedness of gravel, cobbles and/or boulders by fines in stream channel;
- Presence of hummocks.

Trampling may also occur in upland areas. It may be both beneficial and harmful to soils (Naeth et al., 1991, Holecheck et al., 2000). Trampling breaks up soil crusts. A physical soil crust is a thin layer with reduced porosity and increased density at the surface of the soil. They seal the soil surface, reduce the rate of water infiltration, and can increase runoff. The dense nature of the crusts can impede seedling emergence. Trampling can help to incorporate the plant material above the ground into the soil. In arid ecosystems, however, less plant material may be available for incorporation.

A biological soil crust is a living community of lichen, cyanobacteria, algae, and moss growing on the soil surface and binding it together. Biological crusts stabilize the soil surface, protecting it from erosion. In

semiarid ecosystems, biological crusts can provide a significant amount of nitrogen for plant growth (Belnap, 1997). Preventing degradation of biological soil crusts by minimizing disturbance is important.

The following features may indicate trampling in an upland area:

- Absence of or diminished soil surface decomposing organic matter or biological crust;
- Terracing of hill slopes;
- Presence of hummocks.

Soil Nutrient Cycling

Soil nutrients consist of soil organic matter and soil biota. Soil organic matter is carbon-rich material that includes plant, animal, and microbial residue in various stages of decomposition. Soil biota includes micro-organisms (bacteria, fungi, and algae) and soil "animals" (protozoa, nematodes, mites, springtails, spiders, insects, and earthworms), that can live in soil. Soil organisms play a role in the decomposition of plant, root, and animal residue.

Soil organic matter and soil biota enhance soil functions and environmental quality because they (USDA, Natural Resources Conservation Service, 2001, Rangeland Sheet 6):

- Bind soil particles together into stable aggregates, thus improving porosity, infiltration, and root penetration and reducing runoff and erosion;
- Enhance soil fertility and plant productivity by improving the ability of the soil to store and supply nutrients, water, and air;
- Provide habitat and food for soil organisms;
- Reduce physical soil crust formation and runoff;
- Reduce the negative water quality and environmental effects of pollutants by actively trapping or transforming them.

The following indicators may be used to recognize possible soil nutrient and cycling problems:

- Over utilization of forage vegetation;
- Animal waste concentrated in shade, riparian, and feed areas;
- Reduced plant growth and vigor;
- Absence of or diminished soil surface decomposing organic matter or biological crust;
- Conversion of vegetation to annual or invasive plants;
- Loss of topsoil due to erosion;
- Erosion pavement.

Water Erosion

Water erosion is the detachment and removal of soil material by water. Sheet erosion is the more-or-less uniform removal of soil from the surface. Rill and gully erosion occurs when concentrated runoff cuts conspicuous channels into the soil.

Erosion is caused by the impact of raindrops on bare soil and by the power of running water on the soil surface. Natural erosion rates depend on inherent soil properties, slope steepness, slope length, and climate, which together determine the ability of the site to support vegetation. The risk of water erosion may be increased by fire, by soil disturbances, or by the establishment of weeds. Accelerated water erosion occurs when the plant cover is depleted, the spaces between plants become larger, and soil structure is degraded by compaction, excessive disturbance, or reduced inputs of organic matter (Gill et al., 1998).

Water erosion removes or redistributes topsoil, the layer of soil with the greatest amount of organic matter, biological activity, and nutrients. The ability of a plant community to recover after topsoil is lost is restricted. Erosion of nutrient-rich topsoil can cause a shift to less desirable plants, such as from grass to shrub species. Erosion of shallow soils can decrease the thickness of the root zone and the amount of air, water, and nutrients available to plants. The sediment removed by erosion can accumulate in streams, rivers, and reservoirs; and degrade water quality.

Visual indicators that may be used to identify water erosion include (USDA, Natural Resources Conservation Service, 2001, Rangeland Sheet 9):

- Bare soil;
- Pedestaled plants or rocks;
- Exposed roots;
- Terracettes (benches of soil deposited behind obstacles);
- An increase in the number and connectivity of waterflow patterns between plants;
- Soil deposition at slope changes;
- Changes in thickness of topsoil or exposure of subsoil at the surface;
- Rills, head cutting, and/or downcutting in gullies;
- Sediment in streams, lakes, and reservoirs;
- Reduced plant growth.

The following indicators may be used to predict where accelerated water erosion is likely to occur in the future:

- Water Erosion Factor K;
- An increase in the amount of bare ground or in the size or connectivity of bare patches;
- Reduced soil aggregate and soil surface stability;
- Reduced water infiltration.

Wind Erosion

Wind erosion is the physical wearing of the earth's surface by wind. Wind erosion can occur only when wind speed at the soil surface is sufficient to lift and transport soil particles. Loss of soil by wind erosion is a concern for the same reasons as those for water erosion. The risk of wind erosion may be increased by fire, by soil disturbances, or by the establishment of weeds.

Soils are more susceptible to wind erosion where disturbance exposes individual particles and soil aggregates to the wind. Moist soils and soils with stable aggregates or rock fragments are less likely to be eroded than other soils. When soil crusts are crushed or broken apart by soil disturbances such as as animal activity, vehicle or foot traffic, and water erosion, soil particle movement begins at the lower wind speeds (Belnap, et al., 1998 and Leys, et al., 1998). A cover of plants disrupts and helps to reduce the force of the wind.

The following conditions may increase the susceptibility of the soil to wind erosion (USDA, Natural Resources Conservation Service, 2001, Rangeland Sheet 10):

- A reduction in the plant cover, biological crusts, and litter, resulting in bare soil;
- A decrease in the amount of organic matter in the soil, causing decreased aggregate stability;
- Crushed or broken soil surface crusts during windy periods;
- Long, unsheltered, smooth soil surfaces.

Visual indicators that may used to identify wind erosion include:

- Bare soil;
- Wind-scoured areas between plants;
- A drifted or rippled soil surface;
- Loose sand on physical crusts or biological crusts buried by soil;
- Pedestaled plants or rocks;
- Exposed roots;
- Soil deposition or litter movement to the leeward side of plants and obstacles;
- Exposure of subsoil at the surface;
- Reduced plant growth;
- Dust clouds.

When measured over time, the following indicators may be used to predict where accelerated wind erosion is likely to occur in the future:

- Wind Erodability Group and Wind Erodability Index;
- An increase in the amount of bare ground or in the size of bare patches;
- Reduced soil surface stability;
- A reduction in the amount of organic matter.

A series of flowcharts illustrating the preceding soil quality indicators can be found in the Project Record.