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D8 VEGETATION

D8.1 Introduction

This report presents the results of vegetation studies conducted on the Lost Creek Permit Area during the 2006 and 2007 growing season. The study design for the Project follows the information presented in the WDEQ Guideline No. 2 for Vegetation Studies. Prior to the initiation of field work for the Project, the study design was reviewed and accepted by Mark Moxley of the WDEQ (Moxley, M. Lander Field Office Supervisor, WDEQ-Land Quality Division (LQD) Lander Field Office. Personal communication. June 2006). The study design is presented in **Attachment D8-1** of this report. The work for the Project was conducted by Dr. Warren Keammerer, Senior Plant Ecologist at Keammerer Ecological Consultants, Inc., Boulder, Colorado.

The planned Permit Area was expanded in early 2007, and the vegetation survey was extended to include the Permit Area expansion during the 2007 growing season. Field work for 2007 consisted of preparing and field checking a vegetation map of the Permit Area expansion. Since the vegetation types that occurred in the Permit Area expansion were the same as those in the original Permit Area, no additional sampling was conducted. This approach was deemed acceptable by WDEQ (Moxley, M. Lander Field Office Supervisor, WDEQ-LQD Lander Field Office. Personal communication. April 2007).

D8.2 Description of the Study Area

The Permit Area is located near the center of the Great Divide Basin and occurs at an elevation of approximately 7,000 feet above mean sea level. The National Weather Service (NWS) meteorological station closest to the Permit Area with a long period of record is the Muddy Gap, Wyoming station (HPRCC, 2007a). This station is 28 miles northeast of the Permit Area, and temperature, precipitation, snowfall, and snow depth data have been collected since 1949. The Lost Soldier meteorological station, located 12 miles northeast of the Permit Area, collected wind speed and directional data from May 2006 through April 2007, and a meteorological station was installed on the Lost Creek Permit Area in May 2007. As discussed in **Appendix D4 (Climatology)**, the mean annual precipitation was ten inches. The prevailing monthly wind direction was from the west-northwest and west for most of the year, with some variability occurring in the spring. The annual average wind speed at a height of ten meters was 20.7 feet per second (6.3 meters per second).

Most of the site consists of flat upland areas and gentle south facing slopes that are dissected by southerly-flowing ephemeral washes. There are no perennial streams on the Permit Area. The vegetation is dominated by big sagebrush (*Artemisia tridentata*) which occurs throughout both upland and lowland environmental settings. Big sagebrush is well adapted to the cold winter temperatures and limited precipitation that characterize the Permit Area. Numerous other species occur, but none are as successful as big sagebrush. Because of the differences in the density and stature of big sagebrush on the site, two vegetation types were identified and mapped: Upland Big Sagebrush Shrublands and Lowland Big Sagebrush Shrublands. These vegetation types were defined on the basis of topographic position, with the Lowland Big Sagebrush type occurring in the deeper soils along the ephemeral drainages that cross the Permit Area.

Limited amounts of annual precipitation (less than ten inches) and freezing winter temperatures create a cold desert climate which tends to restrict vegetation development. Plant communities tend to be dominated by shrubs, cushion plants or cacti rather than by herbaceous species.

D8.3 Methods

D8.3.1 Vegetation Type Identification and Mapping

Vegetation types were identified following an initial reconnaissance of the Permit Area. Field observations suggested that two different sagebrush types could be mapped in the Permit Area. Aerial photographs at an approximate scale of one inch equals 500 feet were used as base maps for portraying the different vegetation types. The vegetation map was initially prepared based on interpretation of the aerial photos. The final map was prepared after the initial map was checked in the field. The following vegetation types were mapped on the Permit Area: Upland Big Sagebrush Shrubland and Lowland Big Sagebrush Shrubland.

D8.3.2 Species Composition

Species composition was determined by recording a list of all the species that were observed at the Permit Area. Trips were made to the site in May, June, July and September. As part of the field work conducted at these times, observations were made regarding overall species composition observed along the transects and around the Permit Area. In the list of species that was prepared, the individual species were separated into the following life form groups:

- Native Cool Season Perennial Grasses and Grasslike Plants,
- Perennial Forbs (Native and Introduced),
- Cushion Plants,
- Semi-Shrubs,
- Cacti,
- Shrubs, and
- Lichens.

While cushion plants may be considered to be perennial forbs or possibly semi-shrubs, a separate category was used because of the prevalence of this life form type on the Permit Area.

In addition to preparing lists of all observed species, data on species diversity were also recorded along each of the sampled transects. All of the species that occurred along the sampling transects and all species that occurred within one meter of either side of the transect line were recorded. These data were tabulated by computing the mean number of species that occurred in the 50 square meter area defined by the transect line and the one meter distance on either side of the line.

D8.3.3 Sampling Design

The sampling design for the Permit Area called for no distinction between non-affected and disturbed areas. With this sampling design, two vegetation types were sampled at the Permit Area. Data collection for the Permit Area consisted of obtaining vegetation cover data, density data for shrubs, semi-shrubs and cacti, and a complete inventory of trees. Based on discussions with the WDEQ, it was agreed that collection of biomass production data would not be required. A copy of the agreed upon scope of work is presented in **Attachment D8-1**.

No control areas or reference areas were established. For future evaluations of revegetation success, extended reference areas (any of the remaining non-affected portions of a vegetation type disturbed by mining activities within the Permit Area) will be sampled to obtain vegetation cover data that can then be compared with reclaimed area results.

D8.3.4 Sampling Times

Vegetation cover, woody plant density, and species diversity data were recorded for the vegetation types on the Permit Area between June 10 and June 12, 2006. Compared with the historic precipitation record, 2006 was a relatively dry year.

D8.3.5 Collection and Analysis of Vegetation Cover Data

Vegetation cover data were obtained using a point intercept approach. In the upland vegetation type, each sampling unit consisted of a 25-meter transect. An optical point sampling device equipped with a set of crosshairs was used to evaluate cover at one-meter intervals along the transect. Observations were made at a distance of 0.5 meters on each side of the transect at each observation point for a total of 50 observation points per transect. Hits on vegetation were recorded by species. ("Hits" consist of what appears in the crosshairs of the device. In accordance with WDEQ Guideline No. 2 for Vegetation Studies, only the first hit on each species was recorded.) Other cover categories included plant litter, bare soil and rock. A total of 20 transects were sampled in each of the vegetation types (40 total transects in the Permit Area).

Cover data were summarized by computing the mean cover, relative cover (percent of total vegetation cover), frequency, relative frequency (percent of total transects of occurrence) and range of cover values for each of the species encountered along the transects. Relative cover and relative frequency were summed to obtain an importance value which was used to rank each of the species within each of the vegetation types. Mean values for total vegetation cover, cover by litter, cover by rock, cover by bare soil, cover by litter and rock combined and total ground cover were also computed. In the tabular summary, cover values that are given as "<1 percent" are the species that occurred within one meter of either side of the transect line but were not actually encountered as part of the cover sampling.

D8.3.6 Collection and Analysis of Tree and Shrub Density Data

Shrub and semi-shrub density data were obtained by counting all of the individual plants that occurred within one meter on either side of the transect line that was used for collecting cover data. This approach consisted of establishing a belt transect that was two

meters wide and 25 meters long (a total of 50 square meters). The data from the transects were used to compute the mean number of shrubs and semi-shrubs per square meter, the number per hectare and the number per acre. In addition to shrubs and semi-shrubs, density counts were also made for prickly pear cactus. No trees occurred on the Permit Area.

D8.3.7 Cropland and Prime Farmland Description

There are no croplands on the Permit Area. The area is used for livestock grazing, but no crops are produced. In addition to grazing by domestic livestock (cattle), wild horses, pronghorn, and other wildlife graze the Permit Area.

D8.3.8 Plant Species of Special Concern

Prior to conducting field work on the Permit Area, a literature review was conducted to determine what species of special concern might occur within the study area (**Appendix D8, Section D8-3**). The review identified several species of special concern that occur within the general region. As part of the field work, observations were made on the overall species composition of the area and special attention was paid to examining any unusual micro-environments where rare plant species might occur. In general, the vegetation on the Permit Area is typical and representative of most of the Great Divide Basin and is mostly very homogeneous. No plant species of special concern were found at the Permit Area.

D8.4 Results

D8.4.1 Description of Vegetation Types

The Permit Area is located in the Great Divide Basin, where the vegetation on upland areas is consistently dominated by big sagebrush. The vegetation development on the Permit Area is consistent with these regional patterns. On the Permit Area, two vegetation types dominated by big sagebrush were identified and mapped (**Figure D8-1** and **Plate D8-1**). The areal extent of each of these different vegetation types is presented in **Table D8-1**. In the section that follows, each of the vegetation types is described based on data collected in June 2006 and on general observations made during the site visits.

D8.4.1.1 Upland Big Sagebrush Shrubland Type

The Upland Big Sagebrush Shrubland type covers most of the Permit Area (**Figure D8-1** and **Plate D8-1**). **Figure D8-2** shows an area typical of this vegetation type. Overall this type covers about 3,610 acres, approximately 85 percent of the Permit Area. Areas of the Upland Big Sagebrush Shrubland that will potentially be disturbed during the Project are presented in the **Operations Plan** and mitigation measures are presented in the **Reclamation Plan**. It covers flat areas and the gently sloping south-facing slopes, and its development is not affected by the gentle topography that characterizes the Permit Area. The slope at the sampled transects in this type ranged between zero to six percent (**Table D8-2**). Soils throughout the upland areas are mostly shallow and coarse textured. The only environmental settings on the Permit Area that do not support the Upland Big Sagebrush Shrubland type are the areas along the drainages where the Lowland Big Sagebrush Shrubland type grows.

The major species in the Upland Big Sagebrush Shrubland type is big sagebrush, which occurs at a mean absolute cover of 14 percent, and accounts for 54 percent of the cover by all species. Sandberg bluegrass *(Poa secunda)*, needle-and-thread grass *(Stipa comata)*, Indian ricegrass *(Oryzopsis hymenoides)*, and thickspike wheatgrass *(Agropyron dasystachyum)* occur as the most prevalent perennial grass species. Together, these four species had a mean cover of eight percent and accounted for 31 percent of the cover by all species. Cushion plants are common in this vegetation type, but collectively accounted for only six percent of the cover by all species (**Table D8-3**). Even though the mean cover values for these species are low, they were commonly encountered along all the sample transects. The mean total vegetation cover in this type was 26 percent, the cover by litter and rock combined was 22 percent, the bare soil category was 52 percent, and the total ground cover (vegetation plus litter and rock) was 48 percent. The percent cover by bare soil is a reflection of the sparseness of the vegetation in the Upland Big Sagebrush Shrubland type. Even though there is a considerable amount of bare soil, the vegetation development is very homogeneous across the upland parts of the Permit Area. In general, vegetation development in the region is restricted because of the limited amount of annual precipitation.

Shrubs are abundant in this vegetation type. Big sagebrush occurred at a density of 12,332 individuals per acre (about three individuals per square meter) and rabbitbrush *(Chrysothamnus viscidiflorus)* occurred at a density of 1,490 individuals per acre (0.4 individuals per square meter). While these shrub species occur at high densities, none of the plants are tall. In general, most of the plants are less than 0.5 meters in height and many are less than 0.25 meters in height. Semi-shrubs are also common in these upland

areas. The total density for semi-shrub species was 2,583 individuals per acre (0.64 individuals per square meter) with winterfat *(Ceratoides lanata)* and prickly gilia *(Leptodactylon pungens)* occurring as the most prevalent of the semi-shrub species (**Table D8-4**).

In all, 36 species were observed in the Upland Big Sagebrush Shrubland type (**Table D8-5**), with a mean density of about 15 species per 50 square meters. All of the raw data for vegetation cover are presented in Table 1 of **Attachment D8-2**; the raw data for shrub density are presented in Table 2 of **Attachment D8-2**.

D8.4.1.2 Lowland Big Sagebrush Shrubland Type

The Lowland Big Sagebrush Shrubland type on the Permit Area occurs along and immediately adjacent to the ephemeral drainages that cross the Permit Area from north to south (**Figure D8-1** and **Plate D8-1**). **Figure D8-3** shows an area typical of this vegetation type. Overall this type covers about 610 acres, approximately 15 percent of the Permit Area. Areas of the Lowland Big Sagebrush Shrubland that will potentially be disturbed during the Project are presented in the **Operations Plan** and mitigation measures are presented in the **Reclamation Plan**. The soils along the drainages tend to be deeper than those on the adjacent uplands and thereby have the potential for holding more moisture than the upland areas. The increased potential soil moisture allows for more growth by big sagebrush so that the individual shrubs growing along the drainages tend to be much larger than the shrubs growing on the upland areas. Along some of the drainages, there are individual big sagebrush plants that are more than two meters tall that have stem diameters greater than 20 centimeters. Slope measurements along the sampled transects in this type ranged between zero and three percent, and all of the transects were either flat or had a southerly aspect component (**Table D8-2**).

The major species in the Lowland Big Sagebrush Shrubland type is big sagebrush, which occurred at a mean cover of 31 percent and accounted for 72 percent of the cover by all species (**Table D8-6**). Rabbitbrush had a mean cover of three percent and accounted for eight percent of the total vegetation cover. These two dominant shrub species tend to overwhelm the vegetation to the degree that herbaceous species account for only limited amounts of cover in this type. All native perennial grasses combined had a mean cover of seven percent (16 percent of the total vegetation cover) with Sandberg bluegrass *(Poa secunda)*, thickspike wheatgrass *(Agropyron dasystachyum)*, and squirreltail grass *(Sitanion longifolium)* occurring as the most prevalent perennial grass species. Forb species occur throughout this type, but all occurred at mean cover values that were less than one percent. As a group, all forbs and cushion plants accounted for approximately three percent of the total vegetation cover. The mean total vegetation cover in this type was 43 percent, the cover by litter and rock combined was 34 percent, the bare soil

category was 23 percent, and the total ground cover (vegetation plus litter and rock) was 77 percent. Overall, the vegetation cover in the Lowland Big Sagebrush Shrubland type was 17 percent greater than the cover in the Upland Big Sagebrush Shrubland type.

Shrubs are abundant in this vegetation type. Big sagebrush occurred at a density of 14,417 individuals per acre (3.6 individuals per square meter), and rabbitbrush *(Chrysothamnus viscidiflorus)* occurred at a density of 2,591 individuals per acre (0.6 individuals per square meter). Semi-shrubs occur in this type, but the overall densities are lower than the densities for semi-shrubs in the upland areas. The total density for semi-shrub species was 235 individuals per acre (0.1 individuals per square meter), with prickly gilia *(Leptodactylon pungens)* occurring as the most common of the semi-shrub species (**Table D8-7**).

In all, 43 species were observed in this type (**Table D8-5**) with a mean density of about 13 species per 50 square meters. All of the raw data for vegetation cover are presented in Table 3 of **Attachment D8-2**; the raw data for shrub density are presented in Table 4 of **Attachment D8-2**.

D8.4.2 Sample Site Locations

Sample site locations are shown on the Permit Area vegetation map (**Figure D8-1** and **Plate D8-1**). Specific information about each of the sampling locations at the Permit Area is presented in **Table D8-2**. In all, 40 sites were sampled at the Permit Area.

D8.4.3 Weeds, Selenium Indicators, Endangered or Threatened Species

The WDEQ Guideline No. 2 for Vegetation Studies provides lists of prohibited and restricted noxious weeds, selenium indicators and plant species of special concern. These lists were reviewed and compared with the observed species composition at the Permit Area.

Overall, the Permit Area has very few weeds due to the remoteness of the site and the limited amount of past disturbance, other than two-track roads and drill sites, that has occurred in the area. In reference to the *List of Prohibited and Restricted Noxious (Designated) Weeds* in WDEQ Guideline No. 2, only one noxious weed species, tansy mustard (*Descurainia pinnata*), was noted on the Permit Area (**Table D8-8**). Tansy mustard is designated as a restricted noxious weed and was observed as scattered individuals in the Lowland Big Sagebrush Shrubland. Tansy mustard was not actually encountered as part of the cover sampling; however, it did occur within one meter of

either side of five of the 20 Lowland Big Sagebrush Shrubland transects and has a relative frequency of 1.97 percent. No areas dominated by weedy species were observed on the Permit Area. No selenium indicator species were observed on the site. None of the soils on the Permit Area are considered to be seleniferous. No threatened, endangered or plant species of special concern were observed on the Permit Area. A complete evaluation of rare plant species is presented in **Attachment D8-3** of this report.

D8.4.4 Species Composition

As part of all field work, observations were made regarding the species composition in each of the vegetation types (**Table D8-5**). In all, 58 species were observed on the Permit Area. In the Upland Big Sagebrush Shrubland vegetation type, 36 species were noted and in the Lowland Big Sagebrush Shrubland vegetation type, 43 species were noted, indicating a large overlap of species diversity in the two vegetation types. The relatively low number of species is a reflection of the overall homogeneity of the environmental conditions on the site. The Permit Area has limited topographic variability and there are no wetland environments on the site (**Appendix D11**).

D8.4.5 Sample Adequacy

Minimum sample sizes and requirements for sample adequacy are presented in the WDEQ Guideline No. 2 for vegetation studies. The minimum sample size to characterize vegetation cover using point intercept transects is 20 locations.

Twenty random sampling locations were established in each of the following vegetation types: 1) Upland Big Sagebrush Shrubland and 2) Lowland Big Sagebrush Shrubland. After sampling the minimum number of samples, the data for total vegetation cover and total cover were evaluated to determine if the minimum number of samples was sufficient to satisfy the sample adequacy requirements of the WDEQ using the following equation:

$$n_{min} = \frac{2(sz)^2}{(d\bar{x})^2}$$

Where: n_{min} = the number of samples needed adequately sample the type;

s = sample standard deviation;

z = the z statistic (for this application z = 1.28);

d = acceptable amount of inherent variability to be identified between the sample mean and the true population mean (for this application d = 0.1); and

$\bar{x}$ = sample mean.

The results of these calculations are presented in **Table D8-9**. For vegetation cover in the Upland Big Sagebrush Shrubland type, the minimum number of samples required by the sample adequacy equation was 12 and for the Lowland Big Sagebrush Shrubland type, the minimum number of samples was 14. For total cover, the minimum number of samples in the Upland Big Sagebrush Shrubland type was seven and for the Lowland Big Sagebrush Shrubland type, the minimum number of samples was 14. These results show that a sufficient sample size was attained using the required minimum number of samples.

D8.5 Discussion

The vegetation that occurs on the Permit Area is typical and representative of the vegetation within the Great Divide Basin region. The major vegetation types are dominated by big sagebrush which is the major species in the region. Overall, the Permit Area tends to be very homogeneous. The lack of perennial streams and minimal topographic variation restricts the overall species diversity. Since no wetland areas occur, no concentrated grazing was evident within the Permit Area.

The two sagebrush shrubland types tend to intergrade such that the boundaries between the two types are indistinct (**Figure D8-4**). As the soil profile depths become more shallow at the edge of the bottomlands, the big sagebrush plants gradually become smaller and the overall character of the vegetation changes from lowland to upland as the vegetation cover decreases. The smallest big sagebrush plants and lowest cover values occur on the hilltops, where the plants are subject to blowing ice and snow in the winter and the vegetation is dependent on the most shallow soil profiles.

D8.6 Conclusions

- Most of the vegetation on the Permit Area is typical of the vegetation found throughout the Great Divide Basin.
- Very few weeds or weed species were noted on the Permit Area. A few scattered individuals of tansy mustard were noted at the Permit Area. No extensive weedy areas occur.
- No selenium indicator species were observed on the Permit Area.
- No plant species of special concern were observed on the Permit Area.
- A total of 58 species were observed on the Permit Area. Overall, the species composition consisted of species that would be expected in big sagebrush shrublands.
- The Upland Big Sagebrush Shrubland was composed of 26 percent total vegetation cover, 22 percent cover by litter and rock, and 52 percent bare soil.

- Occurring in the deeper soils along the ephemeral drainages, the Lowland Big Sagebrush Shrubland was composed of 43 percent total vegetation cover, 34 percent cover by litter and rock, and 23 percent bare soil.
- Sample adequacy requirements were met in both of the sampled vegetation types.