DES BEE DOVE MINE COMPLEX A CHALLENGE IN THE RECLAMATION OF A PRE-SMRCA SITE[1]

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Abstract: The Des-Bee-Dove Mine complex (owned by PacifiCorp and operated by Energy West Mining Company) had a long and rich mining history beginning in the 1880's. Since development of the mine surface facilities pre-dated SMCRA, initial construction did not include segregation and storage of soils. A total of approximately 13.8 hectares were disturbed prior to the commencement of reclamation in 1999. The goal of the reclamation project was to reclaim the mine site to within approximate original contour (AOC) using existing soil resources excavated on-site and achieve a diverse vegetative stand that would stabilize and protect the reclaimed slopes. Within this disturbed site, there were 14 portal openings necessitating elimination of approximately 762 meters of cut slopes. Also within this site was a 1.0 ha pad constructed into the side of steep canyon walls. This pad alone required approximately 36,000 m^3 to fill to AOC.

With the cooperation of the Utah Division of Oil, Gas and Mining, a comprehensive soil management plan was developed. This plan assessed the quantity and quality of soils available for final reclamation throughout the mine site. The assessment involved excavating a series of trenches, placing them in strategic locations. These trenches were not only utilized to assess the quantity and quality of available substitute soil material, but also to ascertain the characteristics of the subsurface geology. Knowing this geology, approximate locations of natural drainages, rock faces, and drops were determined.

By June 2003, approximately 215,000 m^3 of spoil and suitable soil were moved and placed to achieve the final reclaimed contour. Approximately 272 kg of native seed along with 3,500 bare root and containerized plants were manually planted. All work occurred on slopes with an approximate grade of 2 horizontal to 1 vertical.

Today, three years after the completion of final reclamation, the Des-Bee-Dove Mine complex supports a broad vegetative cover that has protected and stabilized the reclaimed surface. Perennial grasses and woody plant species have begun to outnumber the exotic annuals. As desirable plant species progressively dominate the site, vegetative diversity increases significantly.

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Introduction

The Des Bee Dove Mine complex is located in Southeastern Utah in Emery County, approximately 13 kilometers (8 mi) north of the town of Orangeville, Utah. Geographically, the mine is located on the southern end of East Mountain, a large, relatively flat plateau, containing two mineable coal seams.

Mining began as early as 1898 in the unnamed canyon where the Des Bee Dove Mine complex is located. The original mine workings, called the Griffith Mine, were limited in extent due to the rugged terrain and poor access. The Griffith workings were purchased in 1936 by two men, Edwards and Broderick, who fashioned a crude access road and mined until 1938.

Castle Valley Fuel Company purchased the Edwards and Broderick property in 1938. The Church of Jesus Christ of Latter Day Saints (LDS) purchased coal lands adjacent to Castle Valley Fuel Company in 1938 and began its own operations in that year.

The Church Mine operated under contract to a Mr. Killian of Orangeville until it was closed in 1943 due to World War II. Castle Valley Fuel Company continued to operate until 1947. The LDS Church purchased Castle Valley Fuel's operation in 1947 and combined operations to form Deseret Coal Company, a Church welfare project. Deseret Coal Company continued operations until Utah Power & Light Company (UP&L) acquired the property in 1972.

UP&L operated the mine from 1972 until the mine was temporarily idled in 1987. The property sat idle from 1987 through 1997 as attempts were made to sell the mine and all its assets. In 1997, PacifiCorp, which purchased UP&L in 1992, submitted a Notice of Intent to the Utah Division of Oil, Gas, and Mining (UDOGM) to reclaim the entire Des Bee Dove Mine complex.

The historical use of the Des Bee Dove Mine site pre-dates the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). As surface facilities had been constructed, soils were not salvaged or stored for use in reclamation. As a result, a soil management plan was needed to develop necessary substitute topsoil in a quantity that would cover the 12 hectares (29 ac) of disturbed area.

This document presents the development of the soil management plan and how this plan influenced final reclamation of the mine site. The final reclamation plan was completely rewritten incorporating a new channel design and redesigned fill slopes. More importantly, the plan integrates a soil management plan that justifies the utilization of existing spoils to backfill cut slopes and identifies potential borrow areas for providing a substitute topsoil covering over the entire reclamation site.

Environmental Description

The Des Bee Dove Mine portals and support facilities were developed in steep, nearly perpendicular rock cliffs. Elevation at the mine varies from 2,134 m to 2,286 m (7,000 ft to 7,500 ft) above sea level. Natural slopes in the area range from 5^B to 40^B with the majority of the vegetation occurring on steeper slopes. The area is dominated by rock outcrops, rubble land, and shallow soils. As stated by Dr. A. R. Southard (1980) ANowhere in the vicinity is there a source of material which would usually be referred to as 'topsoil'". Soil tests conducted on the disturbed, undisturbed, and coal waste areas showed that the materials in the portal areas should support selected vegetation. Southard reported three major conclusions:

1. Basically, no topsoil (Horizon A) exists in sufficient quantities to warrant stockpiling (based on undisturbed adjacent areas).
2. Existing materials, selectively, are acceptable as a plant growth medium.
3. Final reclamation would be enhanced, especially sedimentation control, by induced grass species.

Southard classified the soils in the vicinity of the Des-Bee-Dove mine area as: *Typic Ustochrepts-Lithic Ustorthents-Rock Outcrop Loamy-Skeletal, Shallow 40-60% Slopes*

These soils are mostly loamy-skeletal and lithic with areas of sandstone outcrops. In this map unit, Typic Ustochrepts make up about 50%, Lithic Ustorthents about 25% and Rock Outcrop Rubble Land about 20%; included are small areas of Mollisols on north and east facing slopes.

The Ustochrepts can generally be described as follows: pale brown gravelly loam or sandy loam surface layer, with 25% sandstone fragments, 35 cm (14 in) thick, underlain by a pale brown gravelly or stony loam, with 35-50% sandstone fragments, 100 cm (39 in) thick. The Ustorthents are mostly shallow, underlain by rock within 50 cm (20 in) of the surface.

Rubble Lands are those areas where the soils are covered by large boulders so close together that there is little area between the boulders for plants to grow.

Rock Outcrops are exposed areas of bedrock. These areas are often nearly vertical cliff walls in canyons.

Taxonomic classification (reclassified by Southard, May 1989) is loamy-skeletal mixed mesic Lithic Ustorthents. Pedon description is as follows:

A 0-10 cm (0-4 in); pale brown (10YR 6/3) very gravelly loam; olive brown (2.5Y 5/4) when moist; weak, fine granular structure; friable, slightly plastic; few fine, medium, and coarse roots; common fine and few medium pores; 55% gravel; moderately calcareous, carbonates are disseminated; moderately alkaline (pH 8.3); abrupt wavy boundary.

C 10-35 cm (4-14 in); light gray (2.5Y 7/2) extremely flaggy, fine sandy loam, light yellowish brown (2.5Y 6/4) when moist; massive; very friable; few fine, medium, and coarse roots; 40% flagstones; 30% channeres; strongly calcareous; carbonates are disseminated; strongly alkaline (pH 8.8); abrupt smooth boundary.

R 35 cm (14 in); sandstone.

Initial Preparation for Reclamation

After PacifiCorp submitted the Notice of Intent to reclaim the mine site to the Utah Division of Oil, Gas, and Mining (UDOGM) in 1997, Emery County expressed interest in retaining the haul road as part of its county road system. The haul road is utilized primarily for industrial use. However, many recreationalists use the road to access hunting, climbing and hiking activities in the area. In 1998, PacifiCorp and Emery County entered into an agreement to transfer the haul road into the county road system. This cooperative effort resulted in the removal of approximately 40 ha (100 ac) from PacifiCorp=s permit area while allowing industrial use and the general public to access recreational areas. The UDOGM approved a Phase III Bond Release of this area for these purposes.

Since an approved reclamation plan was currently available, final reclamation was initiated in 1999 with the removal of the surface facilities. Structures removed from the site included: bathhouse, warehouse, offices, tipple, belt structures, fan facilities, substations, etc. At the conclusion of this work, 14 mine portals were permanently sealed and backfilled according to the permit stipulations.

Also in 1999, final reclamation was completed on the Pumphouse Area. The Pumphouse Area was an isolated facility located below the main mine site and abandoned in the early 1980's. This 0.7 ha (1.62 ac) site was reclaimed using a rubber-tired backhoe and seeded by hand.

In 2000, current permit requirements necessitated that soil sampling be conducted on five-year intervals at designated locations. Soil sampling of these locations had begun in 1985 to form a baseline soils analysis of the disturbed and undisturbed areas. Sampling continued every five years thereafter comparing the disturbed and undisturbed areas to determine whether surface mining activities were impacting soil quality. Because of the initiation of final reclamation, a decision was made to take additional samples in areas where the potential for soil contamination was high (e.g. tipple/material storage yard, see Fig. 1).

Figure 1: Tipple/Material storage yard pad. Approximately 110,000 tons of coal was buried in this pad.

Additional sampling was conducted using a 20 cm (8 in) truck mounted auger drill. Samples were to be taken on 0.6 m (2 ft) intervals to 1.5 m (5 ft). Three samples would be taken per site; one at 0.6 m (2 ft), one at 1.2 m (4 ft), and one at the extent of the auger hole.

The first sample site was placed on the south end of the tipple/material storage yard. After drilling approximately 1.0 m (3 ft), coal fines begin surfacing from the auger. At 1.5 m (5 ft), full extent of one auger length, coal was still evident. Curiosity dictated that the total depth of the coal be known since this was the area in which a designed channel was planned for construction. A total of 20 m (65 ft) of auger steel (total on truck) was used without finding the bottom extent of the coal. A second sample site was selected approximately 15 m (50 ft) west of the first site. Similar results were realized.

A decision was made to delineate the volume of coal that apparently had accumulated in this canyon in prior years. Drill holes were placed on approximately 15 m (50 ft) centers throughout the extent of the tipple/material storage yard. Cross-sections were established and a volume of approximately 99.8 x 10^6 kg (110,000 tons) of usable coal fines was estimated to be stored in the canyon. In the original reclamation plan, it was proposed to construct a channel through the tipple/material storage yard. However, without the newly obtained drill-hole information, the channel would have been constructed on top of this buried coal pile. A new plan would need to be developed to remove the coal from the canyon and construct the channel on a more suitable base. Figure 1 shows the extent of the buried coal within the storage yard.

In 2001, PacifiCorp obtained permission from UDOGM to remove the coal from the canyon and completely revise the reclamation plan. Coal removal took approximately four months to complete and removed approximately 98 x 10^6 kg (108,000 tons) of high Btu, low ash coal from the canyon. All spoil from this project (approximately 12,700 m^3 or 17,000 cy) was stored on the bathhouse pad and used as fill in that area. As the coal removal project was taking place, PacifiCorp simultaneously began revising the entire Des Bee Dove Mine reclamation plan. The reclamation plan was designed in two separate phases. Phase 1, the upper mine facilities, was designed in-house. The Phase 2 portion was developed with the assistance of a private consulting firm.

Development of the Revised Reclamation Plan

Three separate room and pillar mines existed in the canyon. They were named the Deseret, Beehive, and Little Dove mines. Therefore, the Des Bee Dove Mine complex was established. The Deseret Mine is located in the lower coal seam, referred to as the Hiawatha Seam. The Beehive and Little Dove mines are located in the upper coal seam, referred to as the Blind Canyon Seam. The two seams are in the lower portion of the Blackhawk Formation (refer to Fig. 2), separated by approximately 30 m (100 ft) of interburden. As a result of this interburden thickness, mine portals were developed on separate levels.

Surface facilities to service the portals were developed in each area. The Phase 1 area contained a facilities pad which included two ventilation fans (one for each mine in the upper seam), belt structures, electrical substation, etc. The Phase 2 area contained two facility pads which housed a bathhouse, warehouse, offices, tipple and storage areas.

In the construction of the pre-SMCRA mine complex, no soils were ever salvaged and stored for reclamation. As a result of the coal removal project, a detailed soil management and placement plan was developed to analyze and replace soils on these impacted slopes.

In cooperation with the UDOGM, PacifiCorp developed a comprehensive soil management plan to assess all available soils in the Phase 1 and Phase 2 areas for their potential use as substitute topsoil. The Soil Management Plan called for the excavation of trenches as shown in Fig. 3. PacifiCorp identified ten trenching locations within the Phase 1 and Phase 2 areas for excavation. Trenches were used to determine the quantity of available soils, locate bedrock interfaces, assess the quality of available substitute topsoil, and also to assist in the reconstructed channel design and placement. Trenches were excavated by track-hoe up to 18 m (60 ft.) in length with a maximum depth of 6 m (20 ft.). Some trenches were constructed in two segments with the second portion of the trench assigned the letter AA@ after the trench number. Appendix A exhibits the location of each of the ten trenches. A brief description of the trench locations and identified soil materials are outlined below.

Figure 2: Outcropping of the interburden between the upper and lower mines. The black truck in this figure is parked on the lower mine pad.

Figure 3: Trench #2 developed on the upper mine pad.

Trench locations and Material Descriptions:

#T1 - This trench was located on the Little Dove Mine pad. Materials consisted of gravel and coal fines over a clayey layer, weathered sandstone, and coal. Sandstone bedrock was 0.6 m to 1.2 m (2 ft to 4 ft) in depth.

#T1A -This trench was located in the fill slope and included a portion of the pad at the Little Dove Mine site. A low berm of mixed coal fines and gravel was at the edge of the slope. Materials consisted of gravel and coal refuse in the upper 76 cm (30 in) on the flatter pad portion of the trench. Below was a dark grayish-brown cobbly colluvial material mixed with reddish-brown clayey material and coal waste. Overall texture was loam with spots of clay loam. Also included were some mining waste materials, such as concrete and a few boulders. The outer slope had less coal and gravel at the surface than the pad site and consisted mostly of colluvial fill material.

#T2 -This trench was located on the pad site near the portal of the Beehive Mine. It consisted mostly of waste coal and rock over sandstone bedrock at a depth of 0.9 m to 1.2 m (3 ft to 4 ft). A 6 m (20 ft) section along the end of the trench near the portal had very dark grayish-brown loam soil material of better quality than elsewhere in the trench. It was of limited extent but visually was suitable substitute topsoil material.

#T2A -This trench was located along the fill slope below the Beehive Mine and was similar to T1A. The upper 0.9 m (3 ft) of soil material on the outslope was a dark brown gravelly loam having good root distribution from vegetation. The remainder of the trench consisted of a gravelly surface over mixed colluvium and coal waste. Sandstone bedrock was at about 1.2 m (4 ft) in depth at the end of the trench.

#T3 -This trench was located at the edge of the road at a switchback between the Little Dove/Beehive and Deseret Mines. It was a very small source area for soil material. The surface was mixed coal refuse, gravel and soil material about 40 cm (16 in) thick. Below was a mixed, fairly clayey, multi-colored cobbly colluvial material. At 1.5 m (5 ft) a coal bed was present. Trench depth was to 1.8 m (6 ft).

#T4 -This trench was located at the pad site of the Deseret Mine. Materials consist mostly of coal refuse to a depth of 4.6 m (15 ft) over sandstone. Near the portal there was a portion of dark yellowish-brown colluvial soil material that would be suitable substitute topsoil material but was of limited extent.

#T4A -This trench was located on the fill slope at the Deseret Mine site. It was dug to about 4.6 m (15 ft) in depth and consisted entirely of black coal refuse with a few pockets of dark yellowish-brown soil material.

#T5 -This trench was located at the coal storage site below the Deseret Mine. It consisted of two distinct materials: black coal refuse and dark yellowish-brown stony colluvial material. Sandstone bedrock was at 4.6 m to 6 m (15 ft to 20 ft) in depth.

#T6 -This trench was located along the fill slope and extended into the pad area of the bath house pad site. It was dug to about 4.6 m (15 ft) in depth. Materials were stony colluvium (fill) with some darker colored soil along the surface of the outer slope and in pockets within the trench. Many roots occurred in the soil on the outslope where vegetation was present indicating suitable soil materials for plant growth.

#T7 -This trench was located in the coal waste pile on the bath house pad site. Materials consisted of black coal waste and pockets of dark brown sandy loam. The black coal waste was the major component. The trench was dug to about 6 m (20 ft) in depth.

#T7A -This section of trench was located along the fill slope of the bath house pad near trench #7. The surface was composed mostly of gravel and a gravel/soil mix. Below was stony colluvial fill material.

#T8 -This trench was excavated on the bathhouse pad site near the edge of the coal waste pile. The surface was a mixture of asphalt, coal, road gravel, and rock about 0.6 m (2 ft) thick. Below was a dark yellowish-brown stony colluvial material (fill) which overlies sandstone bedrock at depths of 0.9 m to 2.1 m (3 ft to 7 ft).

#T8A -This trench was located in the fill slope and included as part of the pad (or road) at the bath house site. The surface included mixed coal, soil, and gravel in the berm and gravel and asphalt on the flat surface. These materials extended to about 0.9 m (3 ft) in depth over dark yellowish-brown stony colluvium. Along the outer slope where vegetation was present, the soils had a brown color and were of better quality. Thickness was approximately 0.9 m (3 ft).

#T9 -This trench was dug in a coal waste pile identified as a potential source of substitute topsoil. It consisted of black coal refuse with some sandy soil and sandstone rock fragments mixed in. It was very high in coal content (Total Organic Carbon (TOC) >26%).

#T10 -This trench was located in the storage yard below the load-out site. It consisted of some coarse coal refuse and rock, sandy colluvial type soil, and a mixture of coal refuse and mineral soil. It was a complex arrangement of materials.

Samples were collected that were representative of the various soil materials encountered. Each sample consisted of about ten sub-samples. They were placed in plastic bags for a weight of about 2.7 kg to 3.1 kg (6 lbs to 7 lbs) each. Identification codes ranged from DBD10601 through DBD12801 (Des-Bee-Dove, sample number, year). A total of 23 samples were collected. Seventeen samples were selected for laboratory analysis and submitted to a certified laboratory and analyzed as outlined in the following tables.

Table 1: Parameters for Characterization of the Des Bee Dove Mine Site Soils (UDOGM, 2003)*

TEST TO BE PERFORMED	REPORTED AS	SUGGESTED METHODS
pH	saturated paste standard units	Soil Science Society of America. 1996. Series No. 5. Methods of Soil Analysis: Part 3 - Chemical Methods. Chapter 14, page 420 and Chapter 16, page 487.
Saturation %	%	Ibid. Chapter 14, pp 420 - 422.
EC_e	dS/m @ 25^{o}C (or mS/cm)	Ibid. Chapter 14, pp 420 - 422 and pp 427 - 431.
Soluble Na, K, Mg, Ca	meq/L	Ibid. Chapters 14 pp 420-422 (saturation extract);Chapter 19 pp 555-557; Chapter 20 pp586-590 (spectroscopic methods).
ALKALINITY OF THE SATURATION EXTRACT	HCO_3 mg/L as $CaCO_3$	Western States Laboratory Proficiency Testing Program Soil and Plant Analytical Methods (R.G. Gavlak, et al, 1994). 1998. v 4.10. p 19. (Saturation Paste Extract Alkalinity, titration with 0.02N HCl)
Available NO_3-N	mg/Kg	Soil Science Society of America. 1996. Series No. 5. Methods of Soil Analysis: Part 3 - Chemical Methods. Chapter 38. p 1129 (KCl extraction). For analysis follow: Sims, J.R. and G.D. Jackson. 1971. Rapid Analysis of Soil Nitrate with Chromotropic Acid. Soil Sci. Soc. Am. Proc. 35-603-606.
Available Phosphorus	mg/Kg	Soil Science Society of America. 1996. Series No. 5. Methods of Soil Analysis: Part 3 - Chemical Methods. Chapter 32, page 895. ($NaHCO_3$ Extraction.)
Particle Size Analysis	% sand, very fine sand, silt, and clay	Soil Science Society of America. 1986. Series No. 5. Methods of Soil Analysis: Part 1 - Physical and Mineralogical Methods. Chapter 15 pp 398 and 404-409 (Hydrometer Method).
Organic Matter	%	Western States Laboratory Proficiency Testing Program Soil and Plant Analytical Methods. 1998. v 4.10. p 86. (Loss on Ignition, convert %LOI to OM by regression intercept value as noted in method)
$CaCO_3$ %	%	Ibid. p. 99 (Soil Carbonates, Gravimetric Determination after extraction with 3 M HCl.) Total Inorganic Carbon = %$CaCO_3$ x 0.12.

* Exchangeable Sodium Percentage analyzed when the SAR values are greater than 15 for clay textures and 20 for coarse textured soils.

Table 2: Additional Analyses Required to Characterize the Des Bee Dove Refuse/Coal Mine Waste (UDOGM, 2003).

PARAMETERS	REPORTED AS	RECOMMENDED METHOD
Total Organic Carbon	%	Western States Laboratory Proficiency Testing Program Soil and Plant Analytical Methods. 1998. v 4.10. p 88. (Combustion Method)
Acid Potential	% pyritic S	U.S. EPA, 1978, EPA 600/278-054. Method 3.2.6, pg 60
Neutralization Potential	% $CaCO_3$	U.S. EPA, 1978, EPA 600/278-054. Method 3.2.3, pg 47

Field Parameters:

- Energy West recorded all field information on the NRCS 232 form as outlined in the following Table 3.
- Energy West utilized qualified personnel to direct the field work, sample soil and create composites from samples taken.

Results of Trench Examinations

The results of the soil sampling by an independent soils laboratory were received approximately one month from time of submittal. These data were compared with the evaluation criteria presented above in Table 4. Below, in Table 5, is a summary of the laboratory soil analysis and suitability ratings.

The highest overall ratings based on individual criteria were for samples DBD11401, DBD11801, DBD12101 and DBD12701. For these soil materials, all criteria ratings were good or fair. Samples DBD11401, DBD11801, and DBD12101 were only rated as fair based on percent $CaCO_3$. Sample DBD12701 had fair ratings based on the percentage of CO_3, EC, and TOC.

Table 3: Field Parameters For Characterization of the Des Bee Dove Mine Site Soils (UDOGM, 2003).

TEST TO BE PERFORMED	REPORTED AS	SUGGESTED METHODS
Texture	% sand, silt, clay	U.S. Department of Agriculture, Natural Resource Conservation Service, 1998. Field Book for Describing and Sampling Soils, Version 1.1. p 2-28 - 2-31.
Structure/Consistence	grade, size, type	Ibid. p 2-38 through 2-51.
Visual Estimate % Coal	% area & size fragments	Ibid. p 2-20, 2-26, 7-1, 2-29, and 2-37.
Internal Rock	% volume & size fragments	Ibid. p2-32 through 2-37 and p2-20 and p 2-26.
Surface Rock	% cover & size fragments	Ibid. loc cit.
Soil Color	Hue Value/Chroma	Ibid. p 2-7 through 2-15.
Chemical Response	Effervescence	Ibid. p 2-65.
	Gypsum	U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handbook 60. Method 22a. p102.

Table 4: Substitute Topsoil Suitability Evaluation (UDOGM, 2003).

CRITERIA	GOOD	FAIR	POOR	UNACCEPTABLE
Saturation %	25 to 80		<25 >80	
PH	6.1 to 8.2	5.1 to 6.1 8.2 to 8.4	4.5 to 5.0 8.5 to 9.0	< 4.5 > 9.0
EC (mS/cm 25^{o}C)	0 to 4	4 to 8	8 to 15	> 15
SAR [a,b]	0 to 4	5 to 10	11 to 15	> 15 [a]
%$CaCO_3$	<15	15 - 30	>30	
Texture [c]	sl, l, sil, scl, vfsl, fsl	c, cl, sicl, sc, ls, lfs	sic, s, sc, c, cos, fs, vfs	g, vcos
Total Organic Carbon	<10%			∃10%
Available Water Capacity[d]	> 0.10 moderate	0.05 to 0.10 low	< 0.05 very low	
K factor[e]	< 0.37		> 0.37	
Acid/Base Potential				≤ 0 tons $CaCO_3$ 1000 tons

[a] For clay textured soils unacceptable is SAR >14. For sandy textured soils unacceptable is >20.
[b] For most Western soils, the SAR to ESP relationship is usually 1:1, up to ESP . 20. If SAR>20, then determine ESP. (Evangelou, 2000.)
[c] s=sand, l= loam, si= silt, c= clay, v= very, f= fine, co=coarse, g=gravel
[d] Available Water Capacity is adjusted for texture.
[e] K factor recommendations from the USDA Soil Conservation Service.1978. National Soils Handbook Notice 24. (3/31/78). NSH Part II B403.6(a).

Table 5: Summary of Laboratory Testing Data and Suitability Ratings

PARAMETER	RANGE IN VALUES	SUITABILITY
Saturation Percentage	22.5 to 49.8	All rated as good except sample DBD12501 which rated as poor at less than 25%.
pH	7.2 to 8.1	All rated as good.
EC	1.01 to 9.01 mS/cm	Mostly fair and good; poor for samples DBD11901, DBD12201, and DBD12401 at > 8mmhos/cm.
SAR	0.48 to 11.0	Mostly good; fair for samples DBD12201 and DBD12401; poor for sample DBD12501 at > 10.
%$CaCO_3$	1.4 to 36.3	Mostly fair to poor except for sample DBD10801 (clayey material). Six samples had > 30%. One sample < 19%.
Texture	Clay Loam-Sandy Loam	All rated as good except for sample DBD10801 (clay loam) rating fair.
Total Organic Carbon	0.3 to 26.1%	Four samples high in coal content had > 10% TOC and rated as unacceptable. All others rated as acceptable.
Available Water Capacity	Based on Texture (clay loam to sandy loam)	Most samples rated between 0.10 to 0.18 in/in.
K-factor*	Based on particle size	All samples rated as good.
Acid/Base Potential	16.3 to 369 tons/1000tons	Only one sample (DBD10801) was unacceptable.

*Average portions by particle size are:
Loam B 41% sand, 38% silt, 21% clay (42% silt plus very fine sand).
Sandy Loam - 60% sand, 26% silt, 14% clay (34% silt plus very fine sand).

Poor ratings were based primarily on the percentage of CO_3 and EC. Sample DBD12501 rated poor for EC, SAR, and saturation percent. It was within 1 percent of being poor for its percentage of CO_3 at 29.3 percent. Five samples rated poor based solely on CO_3 with values ranging from 31.0 to 36.3 percent (DBD10601, DBD11001, DBD11101, DBD11301 and DBD11701). Samples DBD11901 and DBD12201 rated poor solely on EC with values of 9.01 and 8.34 mS/cm.

Unsuitable ratings resulted from excessive total organic carbon for four samples that were high in coal content. These were samples DBD10701, DBD12001, DBD12401 and DBD12601. An unsuitable rating was also given to sample DBD10801 for having a low acid/base potential. This was from a clayey layer of limited extent noted above the bedrock at the Little Dove Mine pad site.

Discussion of Trench Examinations

Based on the suitability ratings, the amount of suitable material for substitute topsoil that is rated fair to good was quite limited. The most suitable soil was the upper 0.6 m (2 ft) of soil material on the outslope near the bathhouse site and the mixed coal and soil fill material at the Deseret Mine portal site. Some of the mixed coal and soil at the load-out site (T10) also tested quite suitable, but the material would have been difficult to separate from less suitable material (coal) at the site.

Although rated as poor based on the high carbonate content, four areas within the entire mine site had potential to produce suitable soils for reclamation. These areas are: 1) the soils in the upper 91 cm (36 in) on the outslope near the Beehive Mine (T2A), 2) surface soil at the Little Dove and Beehive Mine pad, 3) colluvial fill material at the Little Dove and Beehive Mine site (T1A, T2A), and 4) the soil materials of trench T5 proved to be acceptable materials for plant growth.

The coal waste material tested fair to good in most respects, but was considered unsuitable for having too high total organic carbon (TOC) content. Mixing the coal refuse with other soil materials could have been conducted; however, the TOC content would need to be reexamined and could not exceed 10 percent.

Variegated clayey material of reddish and yellowish colors such as those noted at the Little Dove Mine pad site (T1) and the access road (T3) was marked to be buried and not allowed to be used as surface (topsoil) material due to physical and chemical characteristics.

The erodibility of the substitute topsoil materials at the mine site was considered low to moderate. This was based primarily on soil properties and rock fragment content. Erosion potential could be quite high when the steep slopes, runoff characteristics, and storm event intensity are all taken into consideration. Surface protection and runoff control is essential to maintaining topsoil in place.

A summary of the suitability ratings and acceptability of each of the soil samples in the assessed trenches is given in Table 6.

Table 6: Assessment of Soil Sample Ratings for Substitute Topsoil Material at the Des-Bee-Dove Mines

Trench	Sample I.D.	Most Restrictive Rating	Acceptable
T1	DBD10601	Poor (CO_3)	Yes-
T1	DBD10701	Unacceptable (TOC) Poor (CO_3)	No+
T1	DBD10801	Unacceptable (ABP)	No
T1A	DBD11001	Poor (CO_3)	Yes-
T2A	DBD11101	Poor (CO_3)	Yes-
T2	DBD11301	Poor (CO_3)	Yes-
T4	DBD11401	Fair (CO_3)	Yes
T5	DBD11701	Poor (CO_3)	Yes
T6	DBD11801	Fair (CO_3)	Yes
T6	DBD11901	Poor (CO_3)	Yes-
T7	DBD12001	Unacceptable (TOC)	No
T7A	DBD12101	Fair (CO_3)	Yes
T7A	DBD12201	Poor (EC)	Yes-
T8A	DBD12401	Unacceptable (TOC) Poor (EC)	No
T8A	DBD12501	Poor (EC, SAR, Sat %)	Yes-
T9	DBD12601	Unacceptable (TOC)	No
T10	DBD12701	Fair (EC, CO_3, TOC)	Yes-

Based on criteria given in October 3, 2001 TA; Table 4 ASubstitute Topsoil Suitability Evaluation@. TOC B Total Organic Carbon, EC B Electrical Conductivity, CO_3 B Carbonates, SAR B Sodium Adsorption Ratio, Sat. % -

With the gathered soils suitability data and information obtained about the locations of bedrock contacts throughout the site, a comprehensive reclamation plan was developed.

Phase 1 Reclamation

Phase 1 Reclamation was initiated in May 2002. Recontouring of the pad area began on the west side and worked east (refer to map Appendix A). The majority of the soil material used in the project was obtained from the outslope of the mine portal pad. Approximately 15,600 m^3 (20,400 cy) were excavated from this area (mostly from the pad outslope) and transported to fill the highwall developed during mining activities. Coal and substandard soils were found buried throughout the Phase 1 area. During the backfilling and grading activities, all unacceptable soil materials were buried at least 1.2 m (4 ft) below the surface and covered with an acceptable soil material.

The subsurface information gained from the trenching procedures proved to be very useful. As reported, a bed rock layer was found below the surface approximately 0.6 m to 1.2 m (2 ft to 4 ft) in trenches T1 and T2. This determination eliminated approximately 61 m (200 ft) of riprapped lined channel bottom. Riprap was used exclusively on the channel banks and within the constructed plunge pools where runoff from the undisturbed channel above cascades onto the reconstructed channel.

As reclamation work progressed to the east side of the pad, excavation uncovered an area where the historic channel had once flowed. It was decided that using the historic channel would pose the least risk to channel failure. The channel was completely excavated to its historic location. When finished, a channel of approximately 6.7 m (22 ft) deep by a width varying between 4.6 m to 7.6 m (15 ft to 25 ft) had been recovered. The length of excavation was approximately 46 m (150 ft). This historic channel contained vertical rock side walls and a solid sandstone bottom. Approximately 2,300 m^3 (3,000 cy) of additional material was uncovered. This additional material provided enough fill to eliminate more highwall than was originally anticipated while still retaining a 2 horizontal to 1 vertical slope as required by the approved reclamation plan. Approximately 1530 m^3 (2000 cy) of excess substitute topsoil material was salvaged and stored for use in the lower mine area of the Phase 2 reclamation area.

Reclamation of the remaining Phase 1 area (i.e. substation pad, water tank pad, access road, etc.) was completed utilizing the existing soil material. A total depth of approximately 0.6 m (2 ft) of substitute topsoil was used to cover the portal pad area. The remaining areas of the Phase 1 reclamation site was covered with approximately 0.3 m (1 ft) of substitute topsoil to complete the backfilling and grading processes. A certified weed-free hay was spread at a rate of 2,250 kg/ha (2000 lbs/ac) over the entire area and incorporated by deep gouging (pocking) in a random and discontinuous fashion. Pockmarks were developed to a size of approximately 0.9 m (3 ft) in diameter and 0.46 m (1.5 ft) deep. The pockmarks capture or trap precipitation, influencing infiltration, and serves to control erosion through water retention and thus, enhancing vegetation growth. The area was seeded by hand and hydromulched with a wood fiber mulch. A tackifier was mixed with the mulch at a rate of 560 kg/ha (500 lbs/ac) to provide additional soil stabilization. Fig. 4 and 5 show how the Phase 1 area looked before final reclamation and after. Phase 1 reclamation was completed in May 2001.

As of the writing of this report, a rich and diverse vegetative stand has developed in the Phase 1 area beyond original expectations. Erosion is controlled and channels remain stable.

Figure 4: Upper mine portal of the Phase 1 area prior to backfilling and grading activities.

Figure 5: Upper mine portal pad of the Phase 1 area after final reclamation.

Phase 2 Reclamation

During Phase 1 reclamation work, the Phase 2 reclamation plan was being developed. The plan focused on burying or utilizing the excess coal waste or spoil that existed throughout the Phase 2 area while creating a stable channel in the exact location as that of the historic channel. Three areas were considered for the utilization of spoil material: 1) backfill excess spoil on the bathhouse pad to cover the large cut slope created during the development of the bathhouse and warehouse facility, 2) backfill and compact excess spoil in the channel bottom, and 3) excavate waste trenches on the bathhouse pad and utilize the substitute topsoil for final cover and bury the excess spoil in the constructed trenches.

As mentioned previously, high quality coal was removed from the canyon leaving a stripped area that measured 300 m x 30 m by 23 m deep (1000 ft x 100 ft by 75 ft deep). Canyon walls were very steep (> 40%). Slope stability analysis allowed constructed fill slopes no greater than 2 horizontal to 1 vertical (2:1) compacted to an in-place unit weight equal to at least 90% of the maximum laboratory density as determined by ASTM D 1997-91. The UDOGM considered the canyon walls to be constructed fill slopes since during construction of the bathhouse pad the material from the cut was displaced over the historic slope.

Slope stability requirements demanded that the channel bottom be backfilled with approximately 9 m (30 ft) of material leaving a proposed constructed slope no greater than 2:1. The reclamation plan was designed to place enough material in the channel bottom to elevate it to a point that would satisfy the 2:1 slope requirement.

Reclamation commenced at the Deseret portal pad (lower mine portal pad) in January 2003 removing spoil material and backfilling along the highwall area as shown in Fig. 6. This area produced a large quantity of spoil. A concrete belt housing structure existed in this area that was demolished and buried against the highwall. Spoil was removed completely to a depth of about 4.6 m (15 ft) which uncovered the sandstone bedrock formation.

Simultaneously, as work was being completed at the lower mine portal pad area, work was also being conducted from the end of the Phase 1 area on the access road toward the lower mine portal pad. Refer to the map in Appendix A. Spoil material from below the access road was excavated and placed against the highwall. All spoil in this area was field analyzed for pH and Electrical Conductivity and was determined non-toxic. Approximately 7,000 m^3 (9,260 cy) of spoil refuse was utilized as backfill in the lower mine portal pad area.

During excavation, large boulders were segregated and used as riprap (D50 ∃ 1.2 m [4 ft]) to construct a plunge pool at the base of the highwall at the center of the canyon. Ephemeral flow in the three channels of the Phase 1 area converge and cascades over the 30 m (100 ft) cliff of the Blackhawk Formation onto this area. The riprap was secured in place by blasting a key-way into the bedrock. When completed, the plunge pool covered and area measuring approximately 25 m (80 ft) long by 15 m (50 ft) wide.

Once the spoil was excavated and contoured, a final soil covering was placed. Since the spoil material analyzed as an acceptable or non-toxic material, a 1.2 m (4 ft) cover was not necessary. The soil salvaged from the Phase 1 area was used to cover the area. However, the volume of soil was only enough to cover a portion of the highwall located along the access road to the upper mine. Additional soil was necessary.

Figure 6: Backfilling highwall with spoil material at the lower mine portal pad.

An area existed between the switchbacks along the road to the upper mine that contained a potential borrow area. The soil in this location had been cast off the side during construction of the access road to the upper mine. This soil was sampled and found to be suitable as a substitute topsoil material. As illustrated in Fig. 7, this soil was stripped to the bedrock and used to cover the remaining highwall area with a substitute soil approximately 0.3 m (1 ft) thick. When completed, the highwall area was pocked, seeded and hydromulched.

Figure 7: Substitute soil excavation between the switchback area of the upper mine

At the completion of the portal pad and upper access road area, reclamation work continued down canyon. Spoil material not backfilled on the portal pad was pushed by dozer down canyon (Fig. 8) to a point where a scraper could access, retrieve and transport the material away.

Figure 8: Removing spoil material by dozer and transporting with scraper down canyon.

As shown in Fig. 9, this material was used to backfill the canyon bottom. When this area was backfilled to an elevation of approximately 9 m (30 ft), the excess material was transported to the bathhouse pad to backfill the cut. The tipple area was excavated to the native material. Spoil material was excavated and used as fill along the west side of the lower mine portal pad and the lower mine yard area. Excess spoil from this area was transported to the bathhouse pad.

Figure 9: Placement and compaction of spoil material in canyon bottom.

During excavation of the main channel, the reclamation plan dictated construction would utilize the bedrock formations and natural drops that were characteristic of the area. This enabled a large amount of good quality soil material to be excavated from the upper part of the channel (Fig. 10). The excavated soil material was field tested and used to cover the spoil material backfilled on the west side of the canyon. A depth of cover up to about 1.2 m (4 ft) was achieved.

Figure 10: Commencing excavation of the upper channel to uncover the bedrock contacts.

The bathhouse pad, as shown in Appendix A, illustrates two borrow areas for proposed substitute topsoil: 1) the outslope of the pad and 2) excavated trenches. The trenches were excavated first. Approximately 6,350 m^3 (8,300 cy) of substitute material was excavated and stored in the mine yard area. This soil was to be used as a topsoil cover for the tipple area. The outslope area of the bathhouse pad was utilized for covering the imported spoil material which nearly filled the 762 m (2500 ft) long cut in that area. An estimated 6,650 m^3 (8,700 cy) was borrowed from this area. Additional soils from the bathhouse pad (e.g. drainage areas, etc.) combined to cover the entire area. The thickness of the topsoil in this area varied between 0.3 m and 0.6 m (1 ft and 2 ft). Fig. 11 shows the excavation and covering techniques used to place topsoil on this slope. The two other borrow areas shown north of the bathhouse area were not utilized since sufficient substitute topsoil was found at a more efficient location, the bathhouse slope.

In an effort to improve the overall final configuration of the bathhouse slope, a decision was made to re-work this area. The advantages of this decision were better slope stabilization, slope grade was reduced from 1.3:1 to 1.9:1 (as-built measurement), increased quantities of substitute topsoil (approximately 7,650 m^3 (10,000 cy), and increased quantity of rock material to construct the main channel. The additional disturbance increased just 0.24 ha (0.6 ac). This work was completed using a dozer and two track-hoes. Figure 12 shows the process which was used to re-work the slope. The equipment traversed back and forth across the slope, over-casting the soil and rock material, while working its way to the canyon bottom.

Figure 11: Covering bathhouse fill slope with topsoil.

Figure 12: Re-working the bathhouse slope. Equipment traverses back and forth casting material to bottom of canyon.

As loose soil and rock cascaded to the bottom of the canyon, a dozer was stationed at the bottom to segregate the rock material from the soil material. Boulders were pushed to the side and sized according to the channel design requirements. Soil material was pushed by dozer up the east slope to cover the exposed side slopes that remained following the coal removal project. All soil from the bathhouse slope was utilized on the slopes on the opposite of the canyon as well as within the channel itself. As work progressed down the slope off the bathhouse pad, the areas were roughened, seeded and hydromulched.

As contouring of the slopes was completed, final construction of the main channel commenced. Two sections of the main channel were simultaneously worked from north to south and from south to north (reference the area map in Appendix A). The connection of the channel was made in the location of the access road and main channel.

The remaining reclamation consisted of the removal of approximately 1220 m (4,000 ft) of the main access road. The existing side cast material was utilized to backfill road cuts. The area was pocked, seeded and hydromulched as shown in Fig. 13.

Figure 13: Reclamation of the main mine access road utilizing existing soil material.

Conclusion

The historical Des Bee Dove Mine site pre-dates the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). During development, facilities were constructed on the site without any thought of reclamation. No topsoil or subsoil were ever stripped, segregated or stored for reclamation. Coal, rock, spoil and miscellaneous non-coal waste was distributed throughout the area and used to construct facility pad areas and buried in valley fills.

Through the development of a soil management plan, quality substitute soils were identified and utilized successfully in sufficient amounts to cover all areas of the mine site disturbance. Approximately 215,000 m^3 (281,210 cy) of spoil and suitable soil were moved and placed to achieve the final reclaimed contour. Figure 14 illustrates the site as it looked in 1999 prior to the start of reclamation work. Figure 15 illustrates the site as it looked in August 2005. Approximately 270 kg (600 lbs) of native seed along with 3,500 bare root and containerized plants were manually planted. Most all work occurred on slopes with an approximate grade of 2 horizontal to 1 vertical.

Figure 14: Des Bee Dove mine complex prior to reclamation in 1999.

Figure 15: Des Bee Dove mine complex after the completion of reclamation. Photo taken in 2005

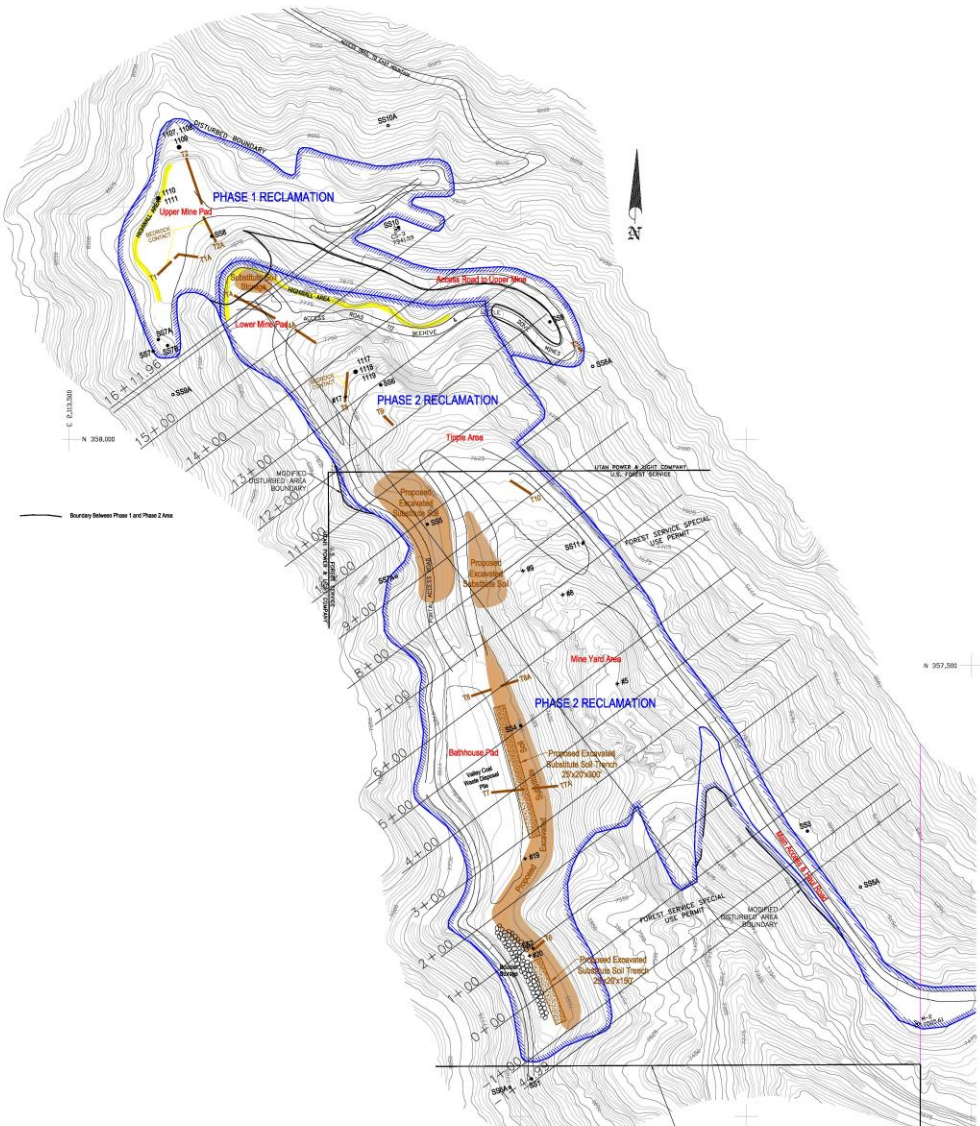
Today, three years after the completion of final reclamation, the Des-Bee-Dove Mine complex supports a broad vegetative cover that has protected and stabilized the reclaimed surface. Perennial grasses and woody plant species have begun to outnumber the exotic annuals. As desirable plant species progressively dominate the site, vegetative diversity increases significantly.

Literature Cited

Southard, A. R. 1980. Des Bee Dove Mine, Soils Study for Utah Power & Light Company, Department of Soils and Biometeorology, Utah State University, Logan, Utah, p. 1.

Utah Division of Oil Gas and Mining (UDOGM), Department of Natural Resources, June 2003, Guidelines for Management of Topsoil and Overburden, R645-301-200: Soils, Draft Document.

R.G. Gavlak, et al, 1994. Plant, Soil and Water Reference Methods for the Western Region, Western Regional Extension Publication (WREP) 125, 58 pages, Western Rural Development Center, Corvallis, Oregon.



Appendix A: Map of mine site soil trench locations, soil salvage locations and soil storage locations.
Note: Contours are post coal removal project.