

APPENDIX D-7

SOILS SURVEY

FOR

PERMIT TO MINE NO. 281C - MINE EXPANSION AREAS

AMENDMENT AREA NO. 7

Prepared for

BLACK HILLS BENTONITE, A LIMITED LIABILITY COMPANY

Ten Sleep Study Area

Prepared by

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APPENDIX D-7
SOILS INVENTORY

Introduction

An inventory and description of the soil resources found on lands associated with this amendment application are provided in this section. The enclosed soils survey and report are titled "Appendix D7 - Soils Survey for Permit to Mine 281C - Mine Expansion Areas - Amendment Area No. 7". This report was originally prepared by Intermountain Resources for Black Hills Bentonite in 1989 and was revised in January 1990 for an update area and in 1997 for Amendment No. 6.

Although this soils inventory was originally conducted and submitted specific to Permit No. 281C 1990 update lands, the lands associated with this amendment were also surveyed during the 1989 field studies. The Ten Sleep lands included in the 1990 Update Area and Amendment Area No. 6 are located immediately adjacent to the Permit No. 281C Amendment No. 7 lands.

The enclosed soils survey report has been revised to include an updated soil survey map showing the soils mapping units on Amendment Area No. 7 lands. The enclosed report also contains detailed descriptions of methodology; mapping units; taxonomic unit profile descriptions; and laboratory data for the soil map units on the Amendment Area No. 7 lands.

SOIL ASSESSMENT

1.0 INTRODUCTION

An Order 2 soil survey was conducted on the study areas as requested by the Wyoming Department of Environmental Quality - Land Quality Division (WDEQ - LQD). The field work was completed in November 1991 by Mr. Bill Glenn of Intermountain Resources. Mr. Glenn is a Certified Professional Soil Scientist with 25 years experience in soil survey work.

2.0 DESCRIPTION OF THE STUDY AREA

The area surveyed is located about 8 miles northwest of Ten Sleep, Wyoming, in Washakie County. The entire study area encompasses 1,260 acres of land which will eventually be amended into Permit No. 281C. Lands within the study area are located in Sections 1, 2, 12 and 13, T.47N., R.90W., and 17, 18, 21, 22, 26, 27 and 35, T.48N., R.90W. The lands contained within the boundaries of this amendment application are included within this 1,260 acre study area.

The area is located in rolling plains and steep breaks on the western edge of the Bighorn Mountains. Site specific locations are shown on the study area maps. Topographic relief is sometimes major with elevations ranging from 4300 to 4800 feet. Precipitation averages 10 to 11 inches per year. The area is used mostly for livestock grazing although mining activities have occurred in the past. Prime farmland does not exist in the area due to lack of precipitation, water for irrigation, and generally poor soils and topography.

3.0 METHODS

This soil survey was conducted according to the general standards of the National Cooperative Soil Survey as outlined in USDA Handbooks 436, 18 and 60, and conforms to WDEQ Guideline No. 1 (November, 1984 Revision), where applicable. Deviations from this guideline were the result of recommendations made by Black Hills Bentonite personnel through their personal communication with WDEQ staff and past bentonite permitting requirements. For this study, the WDEQ required an Order 2 soil survey. The soil survey was more detailed on areas which will be disturbed by mining and less detailed on sites which will not be affected.

3.1 Field Observations

Field observations provided the basis for soils mapping, sampling, and description presented in this report. These observations were primarily obtained from numerous spade and core-auger holes ranging in depth from one to five or more feet which were dug in each map unit delineation. Other observations included associated parent material, vegetation, and position on the landscape.

3.2 Mapping

Field mapping and verification of soils were completed directly on high quality topographic maps and aerial photos. High intensity mapping was employed with delineations as small as two acres where necessary. Vegetation, physiography, and numerous spade and auger holes were used to determine mapping unit boundaries. Constant reference was made to currently available SCS soil series descriptions and ranges of characteristics to maintain a high degree of correlation with other

surveys in the county.

3.3 Mapping Unit Design

Survey techniques were employed to ensure that mapping unit design was compatible to the needs and uses of the survey. A mapping unit in this survey is comprised of either:

1. A single soil series phase or phase of series variant,
2. An association of soil series or phases, or
3. A complex of soil series phases or variants.

The majority of mapping units are consociations and associations comprised of series phases or phases of series variants. Inclusions are also identified in the map units.

Soil complexes were only used where two or more soil and/or land types were so intermixed that delineation was impractical or unnecessary for the intended use of the survey. These complexes usually contain soil types with similar topsoil availability and suitability with similar depths, slopes, and physical and chemical characteristics.

3.4 Sampling and Profile Description

Several previous soil surveys were completed for adjacent lands permitted by Black Hills Bentonite. Where applicable, profile descriptions from these surveys were used in this study. Minor revisions were sometimes needed for these descriptions. Soil sampling data from previous surveys were also applied to this study for homologous soils.

A representative profile from each soil series or series variant was sampled and described in

detail. The representative profile was selected on the basis of median characteristics for parent material, landscape position, physical characteristics and vegetation. Each profile was sampled and described by horizon to a depth of more than 60 inches or bedrock.

A one-quart sample from each soil horizon was collected and air-dried. Soil samples collected were submitted to the laboratory for detailed analyses. Parameters analyzed and the laboratory analyses were completed according to WDEQ Guideline No. 1. (1984 Revision).

4.0 RESULTS

A total of 10 map units were described for the entire 1,260 acre study area. A total of 9 map units were delineated and described on the 155 acres within Amendment Area No. 7.

4.1 Map Units

A list of map units identified in this study and a brief description of each unit are provided below:

<u>Map Unit Symbol</u>	<u>Map Unit Identification</u>
35	Kishona - Shingle Association, 2 to 25 percent slopes
47	Mughut - Bondman Association, 2 to 25 percent slopes
47A	Bondman very flaggy fine sandy loam, 10 to 25 percent slopes
57	Persayo - Rock Outcrop Complex, 15 to 50 percent slopes
61	Rock outcrop - Persayo Complex, 15 to 70 percent slopes (moderately extensive outcrops)

<u>Map Unit Symbol</u>	<u>Map Unit Identification</u>
61A	Rock outcrop - Persayo Complex, 15 to 100 percent slopes (very extensive outcrops)
84	Youngston - Uffens - Lostwells Complex, 1 to 10 percent slopes
DL	Disturbed Lands
RO	Rock Outcrops

Detailed map unit descriptions are included in Addendum D7A.

4.2 Taxonomic Unit Profile Descriptions

Soil profile descriptions are provided for soil taxonomic units found within the study areas.

These descriptions are contained in Addendum D7B.

4.3 Laboratory Data

Laboratory analysis results for soil samples collected from this, and previous study areas are shown in Appendix C. Sample site locations are plotted on the study area maps. This data was combined with field site descriptions to develop topsoil suitability and salvage depths included in the map unit descriptions.

5.0 DISCUSSION

An Order 2 soil survey was completed for Black Hills Bentonite on selected study areas near Ten Sleep Wyoming. Acreage by map unit for soils described within the study areas are

included in Table D7-1. Topsoil suitabilities for these map units are compiled in Table D7-2. Soils descriptions are included in the Addenda attached to this report.

Suitability of soils on these areas is basically limited by slopes, textures, and high sodium adsorption ratio (SAR). Extensive areas have very shallow to shallow depth to bedrock. Many areas are extremely steep which means poorly developed soils and difficulties with salvage. Shale outcrops, rock outcrops, and areas dominated by cobble are also common. There are some soils which are suitable for topsoil salvage. Full advantage will be taken to segregate these suitable soils prior to disturbance. But because the quantity of available soil material is very limited, virtually all soil material will need to be salvaged for use in reclamation, including some soils that classify as unsuitable for use as topsoil.

Table D7-1. Soil Map Unit Acreage for the Permit 281C
Amendment No. 7 Area.

<u>Soil Map Unit</u>	<u>Acres</u>
35	74.7
47	2.4
47A	8.6
57	2.1
61	12.4
61A	6.7
84	43.8
DL	0.3
RO	4.0
Total Acres	155.0

ADDENDUM D7A
SOIL MAP UNIT DESCRIPTION

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Map Unit 35

Kishona - Shingle Association, 2 to 25 percent slopes. This map unit is found on a combination of uplands and fans and is comprised of soils formed from alluvium and weathered shales. Vegetation is primarily big sagebrush and wheatgrasses. Elevation ranges from 4400 to 4700 feet. The average annual precipitation is about 10 to 11 inches, the average annual air temperature is about 45 degrees F, and the average frost-free period is 110 to 130 days.

This unit is approximately 55 percent Kishona soils and 35 percent Shingle soils. Included are Forkwood and Haverdad soils.

The Kishona soil is deep and well drained. The surface layer is grayish brown loam approximately 4 inches thick. The underlying material to a depth of 60 inches or more is light brownish gray loam and may be moderately to strongly alkaline. This soil is usually found at the bottoms of slopes, swales, or drainages.

The Shingle series consists of shallow well drained soils usually found on uplands. These soils formed from weathered shale materials. The surface 4 inches is grayish brown loam or sandy loam. The underlying material to 13 inches is pale brown loam or sandy clay loam. Soft dark gray or olive shales are found below 13 inches.

The Forkwood is a deep well drained soil generally found in valleys and bottoms. The soil varies from sandy loam to sandy clay loam to a depth of 60 inches. The Haverdad is also a deep well drained soil formed in alluvium. This soil is fine sandy clay loam, silty clay loam to 60 inches and sometimes strongly alkaline.

Permeability of this unit is moderate to moderately slow with waterholding capacity generally

moderate to low. Effective rooting depth varies from 10 to 60 inches.

Small bentonite, shale, and rock outcrops also occur within this unit.

Topsoil suitability:

Suitable stripping depths are variable within this map unit. The Kishona soil is generally suitable to 44 inches while the Shingle soil is suitable to 13 inches due to the depth to shale. The Forkwood soil is suitable to 14 inches and marginal below, due to high SAR values. The Haverdad soil may only have a suitable depth of 6 inches because of high alkalinity below that depth.

Map Unit 47

Mughut - Bondman Association, 2 to 25 percent slopes. This unit is found on a variety of aspects including dip slopes, ridges and fans. These soils formed in materials derived from alluvium of sandstones and shales. Dominant vegetation includes big sagebrush, rabbitbrush, and wheatgrasses. Elevation ranges from 4400 to 4800 feet. The average annual precipitation is about 10 to 11 inches, the average annual air temperature is about 45 degrees F, and the average frost free period is 110 to 130 days.

This unit is approximately 40 percent Mughut sandy loam, 25 percent Bondman sandy loam with 25 percent inclusion of very shallow soil over sandstone, and 10 percent Forkwood and Shingle soils.

The Mughut soil consists of moderately deep well drained soil over sandstone and shale. The surface layer to 4 inches is generally brown sandy loam, brown loamy soils are found from 4 to 11 inches and pale brown loam occurs from 11 to 26 inches. Sandstone and shale are encountered below 26 inches.

The Bondman soil is shallow and well drained, formed from sandstone. The surface 3 inches is brown sandy loam, with yellowish brown sandy clay loam from 3 to 12 inches, and yellowish brown sandy loam from 12 to 18 inches. Hard sandstone is encountered below 18 inches.

The very shallow soil type is found on upland areas and is well drained. The soil is brown loam with considerable cobble to a depth of 4 inches, hard sandstone is encountered below 4 inches.

The Forkwood series is deep and well drained. The surface layer is light brownish gray sandy loam while the subsoil is grayish brown to brown loam to 24 inches. From 24 to 60 inches the soil

is light gray sandy loam. This soil is generally found in drainages or swales.

The Shingle soil is shallow, well drained, and generally found on upland sites. This is a loam, sandy loam soil averaging 13 inches in depth. Shale is encountered below 13 inches.

Permeability of soils is moderate and available water capacity is moderate to low. Effective rooting depth varies from 4 to 60 inches depending on site.

Topsoil suitability:

Suitable topsoil for salvage varies considerably with soil type, inclusion, topography, and site. Generally the Mughut soil is suitable to 26 inches or bedrock, the Bondman soil is salvageable to 18 inches or bedrock, the shallow soil type is unsuitable because of shallow depth and cobble, the Forkwood is suitable to 14 inches and marginal below due to high SAR, and the Shingle soil is suitable to 13 inches or depth to rock.

Map Unit 47A

Bondman very flaggy fine sandy loam, 10 to 25 percent slopes. This unit consists of soils occurring on dip slopes. This soil formed in residuum from sandstone and shale. Elevation ranges from 4,300 to 4,800 feet. Vegetation is primarily big sagebrush, threeawn, bluebunch wheatgrass, and prickly pear. The average annual precipitation is about 10 inches, the average annual air temperature is about 45 degrees F, and the frost-free period is 110 to 130 days.

This unit is approximately 90 percent Bondman and similar soils, and 10 percent intermingled inclusions of small sandstone rock outcrops.

The Bondman soil is very shallow and shallow, and well drained. The surface layer is typically brown very flaggy fine sandy loam about 2 inches thick. The upper subsoil is brown fine sandy clay loam about 6 inches thick. The lower subsoil is pale brown and brownish yellow, calcareous, channery fine sandy clay loam about 6 inches thick. Hard sandstone is at about 14 inches of depth.

Permeability of the Bondman soil is moderate and available water capacity is low. Effective rooting depth is 6 to 20 inches.

Topsoil suitability:

Average depth of this soil is about 10 inches. Rock fragments are usually more common on the surface than in the subsoil, but the soil is too thin to selectively handle individual layers. Average rock fragment content in the mixed soil will be about 25 to 50 percent by volume, which causes the soil to classify as marginally suitable or unsuitable for use as topsoil.

However, this soil should be salvaged for use as topsoil, since there usually is no better soil material available within the proposed mine areas. Rock fragments are the only limiting factor and will affect tillage, but the soil can be reclaimed.

Map Unit 57

Persayo - Rock Outcrop complex, 15 to 50 percent slopes. This map unit occurs on dissected, hilly to steep uplands. The scattered areas of soils are poorly developed from shales or sandstone. Elevations range from 4300 to 4800 feet. Vegetation includes big sagebrush, forbs, and wheatgrasses. Average annual precipitation is about 10 inches, the average annual air temperature is about 45 degrees F, and the frost-free period is 110 to 130 days.

This unit is approximately 65 percent Persayo and similar soils, 25 percent rock outcrop consisting of shale, sandstone, and bentonite outcrops, and 10 percent inclusions of Worland soils. The soils occur on vegetated sites, and the rock outcrops are intermingled, nearly barren areas.

The Persayo soil is shallow, well drained, and formed in material derived dominantly from shale and some sandstone. The surface layer is typically light yellowish brown loam about 2 inches thick. Sandstone channers and some flags often occur on the surface. The underlying layer is pale brown clay loam about 8 inches thick, and shale occurs at about 10 inches of depth.

The included Worland soils have 20 to 40 inches of clay loam over shale.

Permeability of the Persayo soil is moderately slow and available water capacity is low. Effective rooting depth is 4 to 20 inches.

Topsoil suitability:

An average of about 10 inches of suitable topsoil above the shale can be salvaged from Persayo soils. No soil occurs on the intermingled rock outcrops. About 20 to 40 inches of soil above the shale can be salvaged from small Worland inclusions.

Map Unit 61

Rock outcrop - Persayo Complex, 15 to 70 percent slopes (moderately extensive outcrops). This unit is generally found on dissected hilly to very steep uplands. Soils are poorly developed form sandstone or shales. Elevations vary from 4300 feet to 4800 feet. Vegetation includes junipers, big sagebrush, forbs and wheatgrasses. Average annual precipitation is about 10 inches, annual temperature is about 45 degrees F, and the average frost-free period is 120 to 130 days.

This unit is approximately 40 percent rock outcrop consisting of areas of sandstone shale, and bentonite outcrops. Persayo soils make up about 40 percent of this unit and inclusions of shallow sandy loam soils comprise about 20 percent of the unit.

The rock outcrops can be found on a variety of slopes and exposures. This type is generally unsuitable for salvage.

The Persayo soil is shallow, well drained, and formed in material derived dominantly from shale and some sandstone. The surface layer is typically light yellowish brown loam about 2 inches thick. The underlying layer is pale brown clay loam about 8 inches thick, and shale occurs at about 10 inches of depth.

The shallow sandy loam soil is well drained and occurs on upland sites near sandstone outcrops. This soil is about 12 inches deep over bedrock.

Permeability of this unit is moderately slow to moderate and available water capacity is low. Runoff is rapid and the hazard of erosion is high. Effective rooting depth is 4 to 20 inches.

Topsoil suitability:

This unit has limitations for topsoil salvage based on rock outcrops and steep slopes. Soil may be salvaged from the Persayo soil (approximately 10 inches) or the similar shallow sandy loam soil (approximately 12 inches) on moderate slopes. Salvage will be very difficult on steep slopes in narrow drainages.

Map Unit 61A

Rock outcrop - Persayo Complex, 15 to 100 percent slopes (very extensive outcrops). This unit is generally found on dissected hilly to very steep uplands. Soils are poorly developed from sandstone or shales. Elevations vary from 4300 feet to 4800 feet. Vegetation includes big sagebrush, forbs and wheatgrasses. Average annual precipitation is about 10 inches, annual temperature is about 45 degrees F, and the average frost-free period is 120 to 130 days.

This unit is approximately 65 percent rock outcrop consisting of almost barren sandstone, shale, and bentonite outcrops. Persayo and similar soils make up about 35 percent of this unit. The shallow soils occur on vegetated patches intermingled with the rock outcrops.

The rock outcrops can be found on a variety of slopes and exposures. This type is generally unsuitable for salvage.

The Persayo soil is shallow and well drained having formed in material derived dominantly from shale and some sandstone. The surface layer is typically light yellowish brown loam to 2 inches, and from 2 to 10 inches pale brown clay loam is generally encountered. Shale occurs at about 10 inches of depth.

Permeability of this unit is moderately slow and available water capacity is low. Runoff is rapid and the hazard of erosion is high. Effective rooting depth is 4 to 20 inches.

Topsoil suitability:

This unit has limitations for topsoil salvage because of rock outcrops and steep slopes. A limited amount of soil may be salvaged from the Persayo soil (approximately 10 inches) on moderate slopes, but salvage will be very difficult on steep slopes in narrow drainages.

Map Unit 84

Youngston - Uffens - Lostwells Complex, 1 to 10 percent slopes. This unit is found on alluvial fans terraces and in valleys. Vegetation is primarily big sagebrush and wheatgrasses. Elevation varies from 4500 to 4600 feet. Average annual precipitation is about 10 inches, average annual frost - free period is from 120 to 130 days.

This unit on the study area is approximately 60 percent Youngston, 30 percent Uffens, and 10 percent Lostwells. The Youngston soil is found on fans, terraces, and the Lostwells soil is on fans and in valleys.

The Youngston soil is deep and well drained, being formed in alluvium. The surface 4 inches is pale brown loam, the soil from 4 to 50 inches is light brownish gray sandy loam, below 50 inches is light brownish gray loam.

The Uffens soil is deep and well drained, formed from alluvium. Typically the surface is pale brown loam, from 1 to 14 inches is pinkish gray clay loam and sandy clay loam, from 14 to 42 inches is pale brown sandy clay loam, and from 42 to 60+ inches is pale brown clay loam. The subsoil is very strongly alkaline and saline.

The Lostwells soil is deep and well drained, also formed from alluvium. The surface 3 inches is brownish gray sandy clay loam. The underlying material to 60+ inches is light brownish gray sandy clay loam stratified with lenses of sandy loam and clay loam.

Permeability of soils within this map unit is moderate to moderately slow, available water capacity is high except for Uffens soils where it is low. Effective rooting depth is 60 inches or more.

Topsoil suitability:

Alkalinity and salinity problems occur in these soils as shown in the high SAR values for lab data on the Younston series. However, an average of 24 inches may be salvaged from this unit without causing problems for plant growth during reclamation.

Rock Outcrops (RO)

Rock outcrops are scattered throughout the area and consist of shale, sandstone, and bentonite outcrops. Some of these areas have been included in the other map units because they are so small and intricately mixed that mapping is impossible at the scale use. Other outcrops and areas with very little soil material were large enough to map out and are designated by this unit/.

Topsoil suitability:

These areas are generally unsuitable as a source of topsoil material.

Disturbed Lands (DL)

Areas impacted by previous mining activities are scattered throughout the study area. These sites consisted primarily of bentonite claim pits, exploration, and mining. These areas were disturbed prior to acquisition by Black Hills Bentonite. Topsoil was not salvaged in these excavations and in most cases topsoil and overburden were pushed down steep slopes where this material is not retrievable. The pits were all left open and no suitable topsoil material occurs on these areas. Other disturbance includes four-wheel drive trails and old haul roads. These areas were too narrow to map out separately.

Topsoil suitability:

Suitable topsoil does not exist on these areas.

ADDENDUM D7 - B

SOIL PROFILE DESCRIPTION

ADDENDUM D7B

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Bondman Series

The Bondman series consists of very shallow and shallow soils on dipslopes. The soils formed in residuum from sandstone and shale. Slopes are 10 to 25 percent.

Taxonomic Class: Loamy, mixed, mesic Lithic ustollic Haplargids.

Typical Location: NE 1/4 NE 1/4 Sec. 2 T47N, R90W;
Sample site KC - 2 - 91.

Typical Profile:

- A - 0 to 2 inches; brown (10 YR 5/3) very flaggy fine sandy loam, dark grayish brown (10 YR 4/2) moist; moderate medium and fine subangular blocky structure; slightly hard, friable non-sticky and non-plastic. Common very fine and fine, and few medium and coarse roots; 20 percent gravels, 30 percent flagstones and cobbles; slightly acid (pH 6.5); clear smooth boundary.
- Bt - 2 to 8 inches; brown (10 YR 5/3) fine sandy clay loam, dark brown (10 YR 4/3) moist; moderate coarse and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine, and few medium and coarse roots; 10 percent sandstone channers; common moderately thick clay films on faces of peds and as bridges between sand grains; mildly alkaline (pH 7.8); abrupt wavy boundary.
- Bk - 8 to 14 inches; pale brown (10 YR 6/3) and brownish yellow (10 YR 6/6) channery fine sandy clay loam, brown (10 YR 4/3) and dark yellowish brown (10 YR 4/4) moist; moderate coarse and medium subangular blocky structure; hard, friable sticky and plastic; common very fine and fine, and few medium and coarse roots; about 35 percent sandstone channers; strongly effervescent; mildly alkaline (pH 7.4); abrupt wavy boundary.
- R - 14 inches; hard sandstone.

Range in Characteristics: Depth to bedrock is 6 to 20 inches. Rock fragments on the surface and in the surface layer range from 20 to 60 percent. The fragments range in size from small gravels to flagstones that are about 2 feet in diameter. Texture of the A horizon is loam or fine sandy loam.

Average rock fragment content in the subsoil ranges from 10 to 35 percent by volume. Texture of the B horizon is loam, fine sandy clay loam, or clay loam.

Topsoil Suitability: Average depth of this soil is about 10 inches. Rock fragments are usually more common on the surface than in the subsoil, but the soil is too thin to selectively handle individual layers. Average rock fragment content of the mixed soil will be about 25 to 50 percent by volume, which causes the soil to classify as marginally suitable or unsuitable for use as topsoil. However, this soil should be salvaged for use as topsoil, since there usually is no better soil material available within the proposed mine areas. Rock fragments are the only limiting factor and will affect tillage, but the soil can be reclaimed.

Kishona Series

The Kishona series consists of deep well drained soils on alluvial fans. These soils formed in alluvium. Slope ranges from 6 to 30 percent.

Taxonomic Class: Fine - loamy, mixed (calcareous), mesic Ustic Torriorthents.

Typical Location: NE 1/4 NW 1/4 Sec. 12 T47N R9OW Site 3

- A - 0 to 4 inches; grayish brown (10 YR 5/2) loam, dark grayish brown (10 YR 4/2) moist; weak, fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots; effervescent; (pH 7.3); clear smooth boundary.
- C₁ - 4 to 44 inches; light brownish gray (10 YR 6/2) loam, dark grayish brown (10 YR 4/2) moist; weak, coarse, subangular blocky; slightly hard, friable, sticky and plastic; few fine and medium roots; effervescent; moderately alkaline; (pH 7.9) gradual smooth boundary.
- C₂ - 44 to 60 inches; light brownish gray (10 YR 6/2) loam, dark grayish brown (10 YR 4/2) moist; massive; slightly hard, friable, sticky and plastic; very few fine roots; strongly effervescent, moderately alkaline (pH 8.2).

Range in Characteristics: Depth to bedrock is greater than 40 inches.

Topsoil Suitability: Salvage of topsoil is suitable to approximately 44 inches.

Mughut Series

The Mughut soil consists of moderately deep well drained soils on convex slopes. They have formed from alluvium and residuum from sandstone and shales. Slopes are 2 to 25 percent.

Taxonomic Class: Fine, montmorillonitic, mesic Ustollic Haplargids.

Typical Location: SE 1/4 SW 1/4 Sec. 1 T47N R90W, Site 1

Typical Profile:

- A₁ - 0 to 4 inches; brown (10 YR 5/3) sandy loam, dark brown (10 YR 3/3) moist; weak fine granular structure; slightly hard, very friable, non-sticky and non-plastic; few fine and very fine roots; mildly alkaline, (pH 7.5) abrupt smooth boundary.
- B_t - 4 to 11 inches; brown (7.5 YR 5/4) loam, brown-dark brown (7.5 YR 4/4) moist; moderate medium prismatic structure parting to medium subangular blocky; hard, fine sticky and plastic; few to many fine and medium roots; clay films on faces of peds; mildly alkaline, (pH 7.4) clear wavy boundary.
- B_{tk} - 11 to 26 inches; pale brown (10 YR 6/3) loam, brown (10 YR 5/3) moist; strong medium prismatic structure parting to strong subangular blocky; slightly hard, friable, sticky and plastic; slightly effervescent; common very fine, fine, and medium roots; clay films on faces of peds; mildly alkaline, (pH 7.8) abrupt smooth boundary.
- R - 26 + inches; sandstone, slightly effervescent.

Range in Characteristics: Depth to bedrock is 20 to 40 inches. Texture of the B horizon is typically clay loam. The clay content in the above profile is lower than typical for the Mughut Series.

Topsoil Suitability: Topsoil is suitable to bedrock with an average of 26 inches salvageable.

Persayo Series

The Persayo series consists of very shallow or shallow well drained soils on uplands. Slopes range from 1 to 80 percent.

Taxonomic Class: Loamy, mixed (calcareous), shallow, mesic, Typic Torriorthents.

Typical Location: NW 1/4 SW 1/4 Sec. 1 T47N R9OW Site 2
and SW 1/4 SE 1/4 Sec. 17 T49N R89W Site 1

Typical Profile:

- A₁ - 0 to 2 inches; light yellowish brown (2.5Y 6/4) loam, sandy loam, light olive brown (2.5Y 5/4) moist; weak fine granular structure sometimes medium platy; soft - slightly hard, friable, sticky and plastic; few to common fine roots; strongly effervescent; neutral (pH 7.2) clear smooth boundary.
- C - 2 to 10 inches; pale brown (10 YR 6/3) sandy loam to clay loam, brown (10 YR 5/3) moist; weak coarse subangular blocky; slightly hard, friable, sticky and plastic; few fine very fine and medium roots; strongly effervescent; mildly alkaline (pH 7.6) clear wavy boundary,.
- C_R - 10 + inches; soft gray, brown, and olive shale.

Range in Characteristics: Depth to shale is from 4 to 20 inches.

Topsoil Suitability: Topsoil is generally suitable for salvage to 10 inches. Limitations may result due to steep slopes.

Shingle Series

The Shingle series consists of shallow well drained soils on upland areas. These soils formed in materials weathered from shale. Slopes range from 2 to 40 percent.

Taxonomic Class: Loamy, mixed, (calcareous), mesic, shallow Ustic Torriorthents.

Typical Location: NE 1/4 SW 1/4 Sec. 1 T47N R90W Site 5
and SW 1/4 NE 1/4 Sec. 12 T47N R90W Site 4

Typical Profile:

- Δ₁ - 0 to 4 inches; grayish brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; weak medium granular structure; soft to slightly hard, friable, sticky and plastic; few to common fine and medium roots; slightly effervescent; mildly alkaline (pH 7.5) clear smooth boundary;.
- C - 4 to 13 inches; pale brown (10YR 6/3) loam, grayish brown (10YR 5/2) moist; weak coarse subangular blocky structure; slightly hard, friable, sticky and plastic; common fine and medium roots; strongly effervescent; mildly alkaline (pH 7.5) clear wavy boundary;.
- Cr - 13 + inches; soft dark gray or olive shale.

Range in Characteristics: Depth to shale ranges from 10 to 20 inches.

Topsoil Suitability: Depth of suitable topsoil averages 13 inches.

Youngston Series

The Youngston series consists of deep, well drained soils on terraces, fans, and flood plains in valleys. The soils have formed in materials from alluvium. Slopes are 1-10 percent.

Taxonomic Class: Fine loamy, mixed (calcareous), mesic Typic Torrifuvent.

Typical Location: SW 1/4 NW 1/4 Sec. 1 T47N R9OW, Site 4
and NE 1/4 NW 1/4 Sec. 12 T47N R9OW, Site 2

Typical Profile:

- A₁ - O to 4 inches; pale brown (10YR 6/3) loam, brown - dark brown (10YR 4/3) moist; weak fine to medium platy and granular structure; soft, very friable, slightly sticky and slightly plastic; few to common fine and medium roots; slightly effervescent; moderately alkaline (pH 7.9) clear smooth boundary.
- C₁ - 4 to 50 inches; light brownish gray (10YR 6/2) sandy loam, grayish brown (10YR 5/2) moist; weak very coarse subangular blocky structure; slightly hard, friable, sticky and plastic; common medium roots; slightly effervescent; moderately alkaline (pH 7.9) gradual smooth boundary.
- C₂ - 50 to 60 + inches; light brownish gray (10YR 6/2) loam, grayish brown (10YR 5/2) moist; massive; slightly hard, friable, sticky and plastic; common very fine and fine roots; slightly effervescent; moderately alkaline (pH 8.1).

Range in Characteristics: Depth to bedrock is generally greater than 50 inches.

Topsoil Suitability: The soil is suitable to 6 inches and marginally suitable to 60 inches. Limiting factor is an SAR value of 14.5 in the lower soil profile.

ADDENDUM D7C

LABORATORY ANALYSIS

WESTERN ENVIRONMENTAL SERVICES AND TESTING, INC.
 6756 WEST URANIUM ROAD
 CASPER, WYOMING 82604
 (307)234-5511

Client: Black Hills Bentonite Company
 Address: P.O.Box 9, Mills, WY 82644
 Attention: Bruce Lawson

Lab #: 88-1132

Sample Type : Soil
 Submitted By:
 Analyzed By :

Date Sampled :
 Date Submitted: 11-15-88
 Date Analyzed : 12-19-88

Subject: Unit 35

Lab #	1132-12	1132-13	1132-14	1132-15
Hole #	Shingle	Shingle	Kishona	Kishona
Interval	0-4"	4-14"	0-4"	4-14"
pH, units	7.51	7.47	7.31	7.88
Conductivity @25C, mmho/cm	0.51	0.45	0.64	1.90
Saturation, %	54.88	56.14	52.20	51.99
Calcium (Ca), meq/L	3.76	2.96	4.48	3.11
Magnesium (Mg), meq/L	0.59	0.49	1.20	1.08
Sodium (Na), meq/L	0.65	0.78	0.56	15.3
SAR	0.44	0.59	0.33	10.6
Boron (B), mg/Kg	0.60	0.66	0.54	0.97
Carbonate (CO3), %	1.61	1.85	0.75	1.15
Organic Carbon (C), %	0.95	0.71	1.09	0.64
Selenium (Se), mg/Kg	0.01	0.01	<0.01	0.02
Coarse Fragments, %	1.6	2.6	11.1	12.1
Very Fine Sand, %	9.7	8.3	8.1	5.4
Sand, %	32.3	39.7	35.9	36.6
Silt, %	34.0	30.0	40.0	38.0
Clay, %	24.0	22.0	16.0	20.0
Texture	Loam	Loam	Loam	Loam

Janet P. Meador
 Chief Chemist

WESTERN ENVIRONMENTAL SERVICES AND TESTING, INC.
 6756 WEST URANIUM ROAD
 CASPER, WYOMING 82604
 (307)234-5511

Client: Black Hills Bentonite Company
 Address:
 Attention: Bruce Lawson

Lab #: 88-1132

Sample Type : Soil
 Submitted By:
 Analyzed By :

Date Sampled :
 Date Submitted: 11-15-88
 Date Analyzed : 12-19-88

Subject: Unit 35 Stop 4

Lab #	1132-18	1132-19
Hole #	Shingle	Shingle
Interval	0-2"	2-11"
pH, units	7.55	7.44
Conductivity @25C, mmho/cm	1.20	3.10
Saturation, %	52.03	58.29
Calcium (Ca), meq/L	7.44	19.1
Magnesium (Mg), meq/L	0.66	1.37
Sodium (Na), meq/L	4.70	15.8
SAR	2.34	4.94
Boron (B), mg/Kg	0.40	0.55
Carbonate (CO ₃), %	1.46	2.48
Organic Carbon (C), %	0.42	0.34
Selenium (Se), mg/Kg	0.02	0.06
Coarse Fragments, %	11.9	11.7
Very Fine Sand, %	13.5	7.4
Sand, %	50.5	60.6
Silt, %	34.0	14.0
Clay, %	2.0	18.0
Texture	Sandy Loam	Sandy Loam

Janet P. Meador
 Chief Chemist

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 (307)234-5511

Client: Black Hills Bentonite Company
 Address: P.O.Box 9, Mills, WY 82644
 Attention: Bruce Lawson

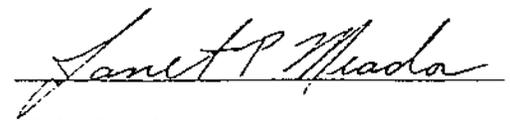
Lab #: 88-1132

Sample Type : Soil
 Submitted By: Bruce Lawson
 Analyzed By : KH, TM, NS, DW

Date Sampled :
 Date Submitted: 11-15-88
 Date Analyzed : 12-19-88

Subject: Unit 47, WH-11-47-90

	1132-5	1132-6	1132-7
Lab #	A1	BJ	B&K
Hole #	0-4"	3-11"	11-26"
Interval			
pH, units	7.52	7.44	7.77
Conductivity @25C, mmho/cm	0.39	0.42	0.58
Saturation, %	38.72	48.36	42.29
Calcium (Ca), meq/L	1.52	1.33	0.90
Magnesium (Mg), meq/L	0.72	0.91	0.61
Sodium (Na), meq/L	1.78	1.75	4.35
SAR	1.68	1.65	5.01
Boron (B), mg/Kg	0.76	0.40	0.69
Carbonate (CO3), %	0.35	1.02	1.23
Organic Carbon (C), %	0.45	0.44	0.37
Selenium (Se), mg/Kg	0.01	<0.01	<0.01
Coarse Fragments, %	16.3	4.0	18.9
Very Fine Sand, %	12.2	6.2	7.2
Sand, %	37.4	31.8	30.8
Silt, %	37.2	42.0	36.0
Clay, %	13.2	20.0	26.0
Texture	Loam	Loam	Loam


 Chief Chemist



InterMountain Laboratories, Inc.

Sheridan, Wyoming 82801

Tel. (307) 672-8945

1633 Terra Avenue

INTERMOUNTAIN RESOURCES
LARAMIE, WYOMING

December 27, 1991

Lab No.	Location	Depths	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture	Organic Matter	Carbonate	Nitrate- Nitrogen	Boron	Selenium
			‡	‡	‡	‡	‡		‡	‡	ppm	ppm	ppm
68860	KC-1-91	0-1	51.7	29.4	61.6	31.5	6.9	SANDY LOAM	1.0	0.6	2.42	0.22	<0.02
68861	Bridgutte	1-6	57.5	14.9	22.7	20.4	56.9	CLAY	1.1	4.7	2.14	1.02	<0.02
68862	KC-2-91	0-2	16.3	15.6	65.5	19.4	15.1	SANDY LOAM	1.3	0.4	2.28	0.22	<0.02
68863	Bondman	2-8	5.5	17.7	59.8	14.2	26.0	SANDY CLAY LOAM	1.2	0.6	4.82	0.14	<0.02
68864		8-14	53.1	15.9	56.2	19.6	24.2	SANDY CLAY LOAM	1.5	12.0	4.68	0.85	<0.02

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1633 Terra Avenue

INTERMOUNTAIN RESOURCES
LARAMIE, WYOMING

Page 1 of 2

December 27, 1991

Lab No.	Location	Depths	pH	EC µmhos/cm @ 25°C	Satur- ation %	Calcium meq/l	Magnesium meq/l	Sodium meq/l	SAR
68860	KC-1-91	0-1	6.8	0.43	28.3	0.65	0.71	3.59	4.36
68861	Bributte	1-6	8.2	1.38	139.	1.08	0.80	17.0	17.6
68862	KC-2-91	0-2	6.5	0.30	30.7	1.47	0.64	0.71	0.69
68863	Bondman	2-8	7.8	1.89	45.4	8.51	3.90	2.98	1.19
68864		8-14	7.4	0.50	49.5	2.93	1.19	0.97	0.67

D7C-5

281C/A6

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, Exch= Exchangeable, Avail= Available

WESTERN ENVIRONMENTAL SERVICES AND TESTING, INC.
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 CASPER, WYOMING 82604
 (307)234-5511

Client: Black Hills Bentonite Company
 Address: P.O.Box 9, Mills, WY 82644
 Attention: Bruce Lawson

Lab #: 88-1132

Sample Type : Soil
 Submitted By: Bruce Lawson
 Analyzed By : KH, TM, NS, DW

Date Sampled :
 Date Submitted: 11-15-88
 Date Analyzed : 12-19-88

Subject: Unit 61

Lab #	1132-1	1132-2	1132-3	1132-4
Hole #	WH1-4790	WH1-4790	WH174789	WH174789
Interval	0-3"	3-8'	0-2'	2-12'
pH, units	7.14	7.59	5.08	4.44
Conductivity @25C, mmho/cm	0.39	0.50	1.70	1.10
Saturation, %	39.99	47.78	52.18	58.20
Calcium (Ca), meq/L	2.04	1.23	3.91	1.21
Magnesium (Mg), meq/L	0.45	0.38	2.14	0.55
Sodium (Na), meq/L	1.94	4.05	9.96	7.53
SAR	1.74	4.51	5.73	8.03
Boron (B), mg/Kg	0.28	0.36	2.47	2.16
Carbonate (CO ₃), %	1.16	3.55	0.41	0.46
Organic Carbon (C), %	0.39	0.48	0.84	0.58
Selenium (Se), mg/Kg	0.02	<0.01	0.01	0.02
Coarse Fragments, %	11.9	2.5	3.0	3.7
Very Fine Sand, %	15.9	8.2	6.0	2.4
Sand, %	52.1	51.8	34.0	37.6
Silt, %	18.0	20.0	34.0	30.0
Clay, %	14.0	20.0	26.0	30.0
Texture	Sandy Loam	Sandy Loam	Loam	Clay Loam


 Chief Chemist

WESTERN ENVIRONMENTAL SERVICES AND TESTING, INC.
 6756 WEST URANIUM ROAD
 CASPER, WYOMING 82604
 (307)234-5511

Client: Black Hills Bentonite Company
 Address:
 Attention: Bruce Lawson

Lab #: 88-1132

Sample Type : Soil
 Submitted By:
 Analyzed By :

Date Sampled :
 Date Submitted: 11-15-88
 Date Analyzed : 12-19-88

Subject:

	1132-16	1132-17
Lab #	unit 84	unit 84
Hole #		
Interval	0-4"	4-50"
pH, units	7.86	7.93
Conductivity @25C, mmho/cm	0.71	5.00
Saturation, %	41.63	56.18
Calcium (Ca), meq/L	1.29	17.1
Magnesium (Mg), meq/L	0.42	4.49
Sodium (Na), meq/L	5.48	47.5
SAR	5.9	14.5
Boron (B), mg/Kg	1.28	3.37
Carbonate (CO3), %	0.91	0.51
Organic Carbon (C), %	0.39	0.50
Selenium (Se), mg/Kg	0.02	0.04
Coarse Fragments, %	6.0	4.9
Very Fine Sand, %	12.2	6.5
Sand, %	27.8	43.5
Silt, %	40.0	48.0
Clay, %	20.0	2.0
Texture	Loam	Sandy Loam

James Meador

Chief Chemist