# CHAPTER 8

# SOILS RESOURCES AND OVERBURDEN

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# CHAPTER 8

# SOILS RESOURCES AND OVERBURDEN

## Introduction

This chapter provides a description of the soils resources on the Black Mesa leasehold including: (1) an overview of the studies that have been conducted; (2) soil identification; (3) maps delineating the different soils; (4) maps delineating topsoil material salvage depths and acreages; (5) soil and map unit descriptions; (6) present and potential productivity of the soils; and (7) evaluation of the soils suitability for use as topsoil materials. This chapter also provides a description of the overburden strata in each mining area and characterizes the quality of these strata with regard to their potential liability to, or resource for, successful revegetation. The quantity of available topsoil material and near-surface overburden for suitable soil supplements is presented in Chapter 22. The potential effects of overburden quality on surface and ground water resources are addressed in Chapter 18.

## Soils Studies

In 1979, Peabody retained Espey, Huston and Associates, Inc. (EH&A) of Austin, Texas, to study the soil resources on and surrounding the Black Mesa leasehold. The study was necessary because no pre-existing soil survey information of the kind and intensity necessary for mine planning purposes was available for the region which includes the leasehold. The only previous study of which Peabody was aware was a soil and range inventory of the 1882 Executive Order Area conducted by the Bureau of Indian Affairs (BIA 1964).

The objectives of the EH&A study were to develop the soils information (maps, soil descriptions and chemical and physical data) necessary to assess the potential for reclamation following coal mining, and characterize the present soils environment within a buffer zone surrounding the mine permit area. Soil scientists from EH&A surveyed the project area at three levels of intensity. An Order 1 survey was made on approximately 1,127 acres of area to be disturbed by mining. An Order 3 survey was conducted on the remaining parts of the leasehold. An Order 4 survey was conducted on a buffer area comprising about 78,000 acres surrounding the leasehold. The project resulted in a report prepared for Peabody (EH&A, 1980) that accompanied a permit application package submitted to the Office of Surface Mining (OSM) in 1981 in support of Permit AZ-0001.

In 1983, Peabody began preparation of a Mine Plan Modification to mine in a previously unpermitted portion of the leasehold. Peabody contracted with Mariah Associates to conduct an Order 2 survey and mapping of those soils in the disturbance area which had potential for use in reclamation. This included the alluvial soils along wash terraces, the valley soils occupying side slopes, and the deeper inclusions of eolian material in the pinyon-juniper woodland. Approximately 4,400 acres were surveyed with the primary objective of characterizing the quality and quantity of topsoil material in the area. The information derived from the project was inserted in the Mine Plan Modification package which was approved upon issuance of Mining Permit AZ-0002A.

In conjunction with the Order 2 soil survey performed by Mariah, Peabody conducted a geobotanical study in the project area. The study was designed to evaluate the potential for selenium toxicity, because selenium accumulating plant species occurred in the baseline vegetation studies.

In 1985, Peabody contracted with Intermountain Soils, Inc. (IMS) to survey all remaining areas to be disturbed on the Black Mesa leasehold during the life-of-mine (as projected thru 2011) and conduct geobotanical studies. The soils in the projected disturbance areas, including a 1,000-foot buffer were surveyed and mapped by IMS. The soils under the pinyon-juniper woodland were mapped at the Order 2 level while the remaining deeper soils were mapped at the Order 1 level. In addition, IMS was contracted to review, consolidate, and standardize the 1979, 1983, and 1985 soil survey data, and prepare a comprehensive summary report on the soil resources of the leasehold. The Scope of Work for this project was reviewed with appropriate personnel from the OSM prior to beginning the fieldwork.

In 2000 and 2003, Peabody Western Coal Company (PWCC) contracted James Nyenhuis, Certified Professional Soil Scientist, to conduct soil surveys of the various remaining life-of-mine coal resource areas and the coal transportation corridors between Black Mesa Mine and the J-23 coal resource area. The report for this Order 2 survey, covering about 18,973 acres, can be found in Appendix A-1.

In summary, the status of the soils resources studies on the Black Mesa leasehold is as follows (Figure 1). Order 4 survey information is available for approximately 78,000

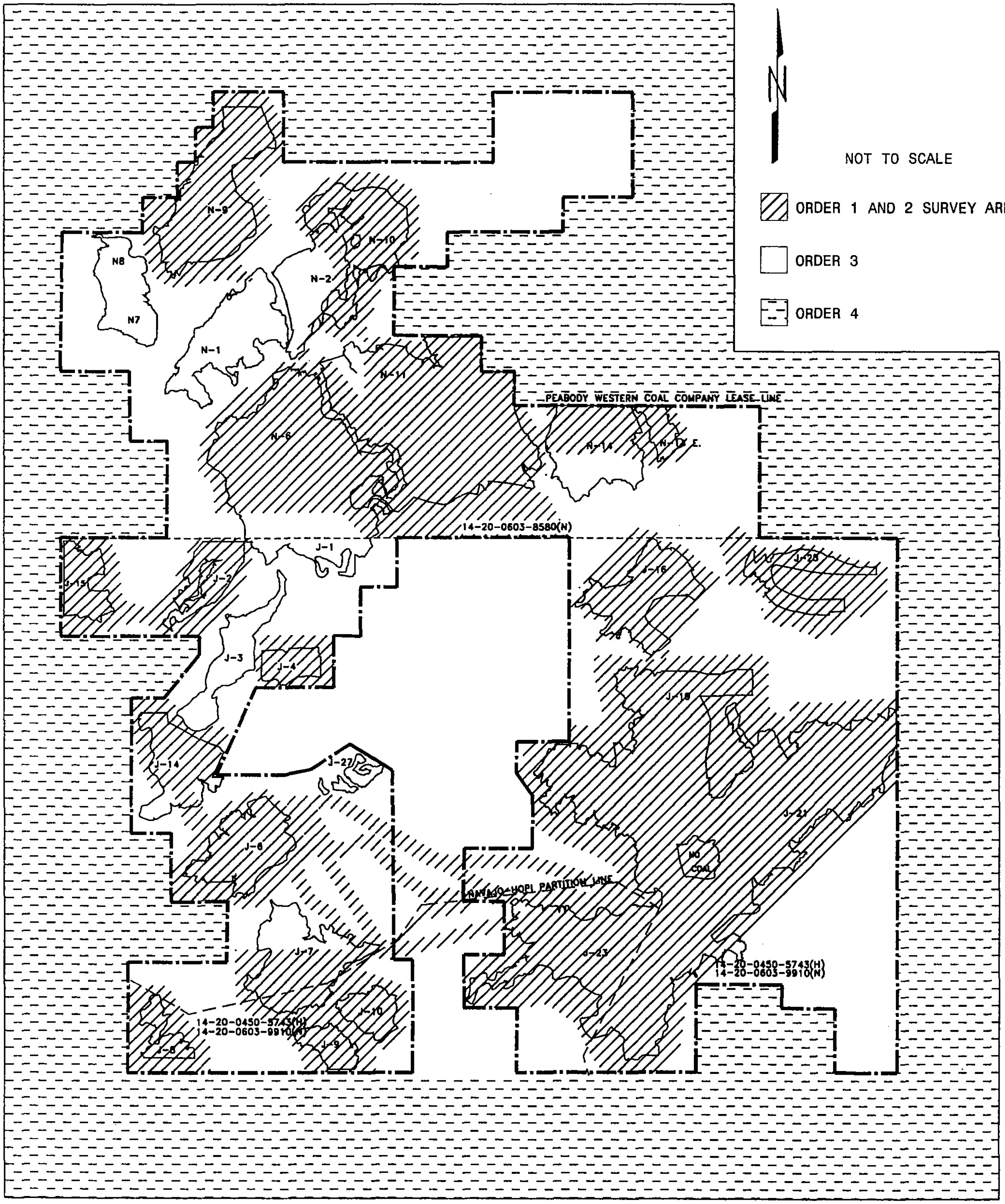


FIGURE 1
SOIL SURVEY AREAS
PEABODY WESTERN COAL COMPANY

REVISED 12/21/2003

acres surrounding Peabody's leasehold. Order 3 survey information is available for approximately 41,026 acres within the leasehold and between Tracts 1 and 2 of the Joint Mineral Use Area leases excluding the proposed mining areas. These surveys characterize the present soils environment surrounding areas to be disturbed. Order 1 and 2 survey information is available for the proposed mining areas plus a 1,000 foot buffer. These surveys characterize the present soils environment in the disturbance areas, assess their chemical and physical quality for use as topsoil material, and determine the quantity of topsoil material available for reclamation purposes. The varying levels of intensity of the surveys in mining areas were required based upon the spatial complexity of the soils relative to their potential for use in reclamation. Geobotanical studies have been completed in all disturbance areas to assess the potential for selenium toxicity.

The comprehensive summary reports prepared by IMS and James Nyenhuis are included in this permit application package as Appendices A and A-1, respectively. The appropriate material in the report has been extracted to prepare the soil resources sections of this chapter. The survey and sampling methods, analytical data, detailed soils descriptions, and interpretation records may be found in Appendices A and A-1.

Soil Identification

Fourteen soils, representing four major soil groups have been identified and mapped in proposed disturbance areas (Table 1). These soils represent the components of less resolved mapping units throughout and surrounding the leasehold. The soil groups are distinguished on the basis of parent materials. These groups include: (1) residual soils derived from interbedded sandstones and shales of the Mesa Verde Formation (refer to Chapter 4 for a complete description of the regional geology); (2) porcellanite-derived soils; (3) eolian soils; and (4) alluvial soils.

The Dulce soil (Table 1) is considered a series taxadjunct because the colors of the soils on the leasehold outlie the range given in the formal description. Two other soils, Soil A and Soil B, could not be classified beyond the family level because no series have been established by the SCS for them. Both are derived from porcellanite.

Based on recent taxonomic reclassification of three soils by the USDA Natural Resources Conservation Service (NRCS) in the last 1990s, the site-specific Peabody soils that were previously named Cahona, Pulpit, and Sharps have been recorrelated. The soil that was

TABLE 1

Taxonomic Classification of the Soil Series Identified

On the Black Mesa Leasehold

| Series | Family |
|---|---|
| Begay | Coarse-loamy, mixed, superactive, mesic Ustic Haplocambid |
| Bond | Loamy, mixed, superactive, mesic Lithic Ustollic Haplargid |
| Cahona (Blanding) | Fine-silty, mixed, superactive, mesic Ustic Haplargid |
| Chilton | Loamy-skeletal, mixed, calcareous, mesic Ustic Torriorthent |
| Dulce[1] | Loamy, mixed, superactive, calcareous, mesic, shallow Ustic Torriorthent |
| Las Lucas | Fine-silty, mixed, active, mesic Ustic Haplocambid |
| Oelop | Fine-loamy, mixed, superactive, mesic Ustic Haplargid |
| Pulpit, ustic-aridic | Fine-silty, mixed, superactive, mesic Aridic Haplustalf |
| San Mateo | Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torrifluvent |
| Sharps, ustic-aridic | Fine-silty, mixed, superactive, mesic Aridic Haplustalf |
| Travessilla | Loamy, mixed, superactive, calcareous, mesic Lithic Ustic Torriorthent |
| Zyme | Clayey, smectitic, calcareous, mesic, shallow Ustic Torriorthent |
| Soil A | Loamy-skeletal over fragmental, mixed, calcareous, mesic Ustic Torriorthent |
| Soil B | Loamy-skeletal over fragmental, mixed, mesic Ustic Haplocalcid |

[1]This soil is a taxadjunct to the series

named Cahona is renamed Blanding. An "ustic-aridic" soil moisture regime modifier has been added to the Pulpit and Sharps soil names (Pulpit, ustic-aridic; and Sharps, ustic-aridic). Because these soils are not new soils, but rather recorrelated to different soil name modifiers, they were not sampled for baseline laboratory characterization following taxonomic reclassification.

Soil Maps

Four sets of soils maps are contained in Chapter 25. Drawing 85300, Sheets 1 through 9, provides the map units and boundaries of the Order 3 and 4 soil surveys. Mapping was conducted at a scale of 1" = 2000' on black and white aerial photography with orthophotoquad topographic line overlay. Drawing 85305A, Sheets 1 through 15, provides the map units and boundaries of the Order 1 and 2 soil surveys conducted in 1979, 1983, and 1985. Drawing 85305B, Sheets 1 through 15 provides topsoil salvage depth delineations for the 1979, 1983, and 1985 surveys. The base map for Drawing 85305A and 85305B is a 1" = 400' scale black and white aerial photograph. The 2000 and 2003 soil survey and topsoil salvage information is presented on Drawing 85305C (11 sheets total). Each base map is a rectified orthophotoquad with topographic contour overlay at a scale of 1″ = 400′.

Soil Series and Map Unit Descriptions

Fifty-four map units were described in the 1979, 1983, and 1985 Order 1 and Order 2 surveys (Table 2; Drawing 85305A, Sheets 1 through 15). Thirty-seven map units were described in the 2000 and 2003 Order 2 surveys (Table 2; Drawing 85305C, 11 sheets total). Seventeen map units were identified in the Order 3 survey and four map units were identified in the Order 4 survey (Table 2; Drawing 85300, Sheets 1 through 9). Map unit descriptions may be found in Appendices A and A-1. Each description provides basic information about the soils in the map unit, such as position on the landscape, type(s) of soil dominating the unit, and contrasting and similar soils which may occur within any delineation. Those descriptions, as originally prepared by EH&A, Mariah Associates, or IMS have been modified by James Nyenhuis only to achieve agreement with the most recent taxonomic classification.

Soil series descriptions for the 14 soils identified in the Order 1 and 2 surveys may be found in Appendices A and A-1. The relevant physical and chemical data and SCS Form 5 Soil Interpretation Records are presented as well.

TABLE 2

Order 1, 2, 3, and 4 Soil Survey Map Unit Legends

| Map Symbol | Map Unit Name |
|---|---|
| **Order 1 and 2 Surveys (1979, 1983, and 1985):** | |
| 1A | Dulce very channery fine sandy loam, 1 to 4 percent slopes |
| 1, 1B | Dulce very channery fine sandy loam, 4 to 8 percent slopes |
| 1C | Dulce very channery fine sandy loam, 8 to 15 percent slopes |
| 1D | Dulce very channery fine sandy loam, 15 to 30 percent slopes |
| 2B | Bond very fine sandy loam, 1 to 8 percent slopes |
| 3A | Zyme-Dulce complex, 2 to 8 percent slopes |
| 3BC | Zyme-Dulce complex, 2 to 15 percent slopes |
| 3C | Zyme-Dulce complex, 6 to 15 percent slopes |
| 3D | Zyme-Dulce complex, 15 to 30 percent slopes |
| 3DE | Zyme-Dulce complex, 15 to 50 percent slopes |
| 3E | Zyme-Dulce complex, 30 to 50 percent slopes |
| 3F | Ustic Torriorthents-Rock outcrop complex, 50 to 80 percent slopes |
| 4A | Zyme very channery loam, 1 to 4 percent slopes |
| 4B | Zyme very channery loam, 4 to 8 percent slopes |
| 4C | Zyme very channery loam, 8 to 15 percent slopes |
| 4D | Zyme very channery loam, 15 to 30 percent slopes |
| 5 | Pulpit very fine sandy loam, 2 to 8 percent slopes |
| 6 | Sharps very fine sandy loam, 2 to 8 percent slopes |
| 6A | Sharps very fine sandy loam, 1 to 4 percent slopes |
| 6B | Sharps very fine sandy loam, 4 to 8 percent slopes |
| 6C | Sharps very fine sandy loam, 8 to 15 percent slopes |
| 7B | Travessilla-Zyme-Dulce complex, 2 to 6 percent slopes |
| 7C | Zyme-Travessilla-Rock outcrop complex, 6 to 15 percent slopes |
| 7D | Zyme-Travessilla-rock outcrop complex, 15 to 30 percent slopes |
| 7E | Zyme-Travessilla-rock outcrop complex, 30 to 50 percent slopes |
| 10 | Cahona very fine sandy loam, bedrock substratum, 2 to 8 percent slopes |
| 10A | Cahona very fine sandy loam, bedrock substratum, 1 to 4 percent slopes |

TABLE 2

Order 1, 2, 3, and 4 Soil Survey Map Unit Legends

| Map Symbol | Map Unit Name |
|---|---|
| **Order 1 and 2 Surveys (1979, 1983, and 1985) (Cont.):** | |
| 10B | Cahona very fine sandy loam, bedrock substratum, 4 to 8 percent slopes |
| 10C | Cahona very fine sandy loam, bedrock substratum, 8 to 15 percent slopes |
| 11 | Cahona very fine sandy loam, 1 to 6 percent slopes |
| 11A | Cahona very fine sandy loam, 1 to 4 percent slopes |
| 11B | Cahona very fine sandy loam, 4 to 8 percent slopes |
| 11C | Cahona very fine sandy loam, 8 to 15 percent slopes |
| G11B | Cahona very fine sandy loam, gravelly substratum, 2 to 8 percent slopes |
| X11 | Cahona-Cahona, bedrock substratum, very fine sandy loams, 2 to 10 percent slopes |
| X11A | Cahona-Cahona, bedrock substratum, very fine sandy loams, 1 to 4 percent slopes |
| X11B | Cahona-Cahona, bedrock substratum, very fine sandy loams, 4 to 8 percent slopes |
| X11C | Cahona-Cahona, bedrock substratum, very fine sandy loams, 8 to 15 percent slopes |
| 12 | Begay loam, 2 to 10 percent slopes |
| 12A | Begay loam, 1 to 4 percent slopes |
| 12B | Begay loam, 4 to 8 percent slopes |
| 12C | Begay loam, 8 to 15 percent slopes |
| 13,13A | San Mateo loam, 0 to 3 percent slopes |
| 14A | Oelop very fine sandy loam, 1 to 4 percent slopes |
| 14B | Oelop very fine sandy loam, 4 to 8 percent slopes |
| 15,15A | Las Lucas sandy clay loam, 2 to 6 percent slopes |
| 16C | Soil A-Soil B extremely channery very fine sandy loams, 4 to 15 percent slopes |
| 16E | Soil A-Soil B extremely channery very fine sandy loams, 15 to 50 percent slopes |

TABLE 2

Order 1, 2, 3, and 4 Soil Survey Map Unit Legends

| Map Symbol | Map Unit Name |
|---|---|
| **Order 1 and 2 Surveys (1979, 1983, and 1985) (Cont.):** | |
| 16F | Soil A-Soil B extremely channery very fine sandy loams, 50 to 70 percent slopes |
| 17C | Chilton gravelly fine sandy loam, 6 to 15 percent slopes |
| DL | Disturbed Land |
| RL | Reclaimed Land |
| TS | Topsoil Stockpile |
| RW | Riverwash |
| **Order 3 Surveys (1979 and 1985):** | |
| 20 | Zyme-Cahona-Dulce association, 0 to 30 percent slopes |
| 21 | Zyme-Las Lucas complex, 0 to 15 percent slopes |
| 22 | Zyme-Las Lucas-Dulce association, 0 to 30 percent slopes |
| 23 | Zyme-Dulce complex, severely eroded, 0 to 30 percent slopes |
| 24 | Zyme-Dulce association, 8 to 30 percent slopes |
| 25 | Zyme-Dulce-Las Lucas association, 0 to 30 percent slopes |
| 26 | Cahona-Zyme association, 0 to 30 percent slopes |
| 27 | Begay-Las Lucas association, 0 to 8 percent slopes |
| 28 | Las Lucas-Zyme-Dulce complex, 0 to 8 percent slopes |
| 29 | Dulce gravelly fine sandy loam, 0 to 30 percent slopes |
| 30 | Dulce-Zyme association, 15 to 30 percent slopes |
| 31 | Dulce-Cahona association, 0 to 30 percent slopes |
| 32 | Dulce-Las Lucas association, 0 to 15 percent slopes |
| 33 | Dulce-Las Lucas-Zyme association, 8 to 30 percent slopes |
| 34 | Pits and dumps |
| 35 | Torriorthents, reclaimed |
| 36 | San Mateo silt loam, 0 to 8 percent slopes |
| **Order 4 Surveys (1979 and 1985):** | |
| 40 | Haplargids-Torriorthents association, undulating to hilly |

TABLE 2

Order 1, 2, 3, and 4 Soil Survey Map Unit Legends

| Map Symbol | Map Unit Name |
|---|---|
| **Order 4 Surveys (1979 and 1985) (Cont.):** | |
| 41 | Torrifluvents, nearly level |
| 42 | Torriorthents, undulating to hilly |
| 43 | Torriorthents, sloping to very steep |
| **Order 2 Surveys (2000 and 2003):** | |
| 1AB | Dulce very channery fine sandy loam, 1 to 8 percent slopes |
| 1CD | Dulce very channery fine sandy loam, 8 to 30 percent slopes |
| 2B | Bond very fine sandy loam, 1 to 8 percent slopes |
| 3AB | Zyme - Dulce complex, 1 to 8 percent slopes |
| 3CD | Zyme - Dulce complex, 8 to 30 percent slopes |
| 3DE | Zyme - Dulce complex, 30 to 50 percent slopes |
| 3F | Ustic Torriorthents - Rock Outcrop complex, 50 to 80 percent slopes |
| 4AB | Zyme very channery loam, 1 to 8 percent slopes |
| 4CD | Zyme very channery loam, 8 to 30 percent slopes |
| 5 | Pulpit very fine sandy loam, ustic-aridic, 2 to 8 percent slopes |
| 6AB | Sharps very fine sandy loam, ustic-aridic, 1 to 8 percent slopes |
| 6C | Sharps very fine sandy loam, ustic-aridic, 8 to 15 percent slopes |
| 7B | Travessilla - Zyme - Dulce complex, 2 to 6 percent slopes |
| 7CD | Zyme-Travessilla-Rock Outcrop complex, 6 to 30 percent slopes |
| 7E | Zyme-Travessilla-Rock Outcrop complex, 30 to 50 percent slopes |
| 10AB | Blanding very fine sandy loam, bedrock substratum, 1 to 8 percent slopes |
| 10C | Blanding very fine sandy loam, bedrock substratum, 8 to 15 percent slopes |
| X11AB | Blanding - Blanding, bedrock substratum, very fine sandy loams 1 to 8 percent slopes |
| X11C | Blanding - Blanding, bedrock substratum, very fine sandy loams, 8 to 15 percent slopes |
| 11AB | Blanding very fine sandy loam, 1 to 8 percent slopes |
| 11C | Blanding very fine sandy loam, 8 to 15 percent slopes |
| G11B | Blanding very fine sandy loam, gravelly substratum, 2 to 8 percent slopes |
| 12AB | Begay loam, 1 to 8 percent slopes |
| 12C | Begay loam, 8 to 15 percent slopes |
| 13A | San Mateo loam, 0 to 3 percent slopes |
| 14AB | Oelop very fine sandy loam, 1 to 8 percent slopes |
| 15A | Las Lucas sandy clay loam, 2 to 6 percent slopes |
| 16C | Soil A - Soil B, extremely channery very fine sandy loams, 4 to 15 percent slopes |
| 16CE | Soil A - Soil B, extremely channery very fine sandy loams, 15 to 50 percent slopes |
| 16F | Soil A - Soil B, extremely channery very fine sandy loams, 50 to 70 percent slopes |
| DL | Disturbed Land |
| P | Pond |
| RL | Reclaimed Land, no topsoil |
| RLT | Reclaimed Land, topsoiled |
| TS | Topsoil Stockpile |
| RD | Reconstructed Drainage |
| RW | Riverwash |

Present and Potential Productivity of the Soils

The soils which occur on the Black Mesa leasehold are predominantly in SCS land capability Classes VI and VII. The land capability class for each soil series is listed on the SCS (NRCS) Form 5 in Attachment 6 of Appendix A. Soils in Classes VI and VII have severe to very severe limitations that make them unsuitable for cultivation and limit or restrict their use largely to pasture, range, woodland or wildlife habitat. Soils in these groupings are used primarily for livestock grazing. The lands on the leasehold have received a negative determination as prime farmland from the SCS (NRCS) (Attachment 1).

Potential rangeland vegetation production can be inferred from the SCS (NRCS) Form 5 Soil Interpretation Records for soils correlated to established series. For a number of soil series, ranges of potential production have been established on the basis of site to site variation in soil moisture availability, the length of the frost-free period and range condition. The potential vegetation production for the soils identified in the Order 1 and 2 surveys have been extracted from the records and are presented in Table 3. Productivity values include both the moist and dry phases of the soils. The potential vegetation production estimates are based upon normal year precipitation and excellent range condition.

Official Form 5's are not available for the Dulce taxadjunct, Soil A and Soil B, since they are not established series. The Dulce Form 5 was used for the Dulce taxadjunct soil because soil color was the only parameter that did not match the official description. The average potential production for the Dulce and Zyme soils was used to estimate the potential productivity of Soil A and Soil B. Soil A and Soil B occur in the same landscape positions as the Zyme and Dulce soils, have similar depths, and support similar vegetation.

The present productivity of the soils on the leasehold is well below that which is estimated under optimum conditions. The 1964 soil and range inventory of the 1882 Executive Order Area conducted by the Bureau of Indian Affairs substantiates this observation (BIA, 1964). The entire leasehold below the Executive Order Area boundary is included in the inventory. The inventory characterized the pinyon-juniper range sites, which include the Zyme, Dulce, and Travesilla soils on the leasehold as having low productive potential and to be in poor condition. The sagebrush-grassland range sites, which includes the deeper alluvial and eolian soils on the leasehold (e.g. Cahona soils)

TABLE 3

SCS Form 5 Potential Vegetation Production

For the Soils Identified in the Order 1 and 2 Surveys[1]

| Soil Series | SCS Form 5 Number | (Potential Production (lb/ac. air dry) Moist Phase | Dry Phase |
|---|---|---|---|
| Begay | UT0359 | 1000 | 650 |
| Bond | NM0220 | 500 | 500 |
| Cahona | C00578 | 1000 | 750 |
| Chilton | NM0223 | 850 | 850 |
| Dulce | C00394 | 600 | 600 |
| Las Lucas | NM0090 | 675 | 675 |
| Oelop | NM0488 | 750 | 750 |
| Pulpit | C00538 | 800 | 600 |
| San Mateo | NM0854 | 750 | 750 |
| Sharps | C00310 | 1200 | 600 |
| Travessilla[2] | NM0690 | 225 | 225 |
| Zyme[2] | C00749 | 400 | 300 |
| Soil A | - | 500 | 450 |
| Soil B | - | 500 | 450 |
| Ustic Torriorthents | C07057 | 350 | 350 |

[1]Normal precipitation year; annual production for shrubs, half-shrubs, grasses and forbs.

[2]Channery surface

were characterized as having medium to high potential, but to be in poor to fair condition. The inventory found 1,420,401 acres to be in poor conditions, 328,535 to be in fair condition, and none to be in good or excellent condition.

The results of production samples conducted in the native plant communities on the leasehold further support the observation that the present productivity of the soils is low (Chapter 9). Approximately 119 to 190 acres of pinyon-juniper woodland range are required to support one animal unit for one month. Approximately 10.5 to 13 acres of sagebrush range are required to support one animal unit for one month with a high proportion of sagebrush in the diet. These figures reflect directly on the current poor condition of the soils. The low productivity of the soils on the leasehold is due to the eroded condition of the soils and the retrogressive composition of the vegetation. These conditions in turn have been caused by severe overgrazing of soils that are inherently susceptible to erosion. The loss of the soil resource is so severe that it is doubtful that most of the land will ever recover productivity levels near its potential, even under intensive management.

Topsoil Material Suitability Evaluation (1979, 1983, and 1985 Soil Surveys)

By definition, topsoil means the A and E soil horizon layers of the four master soil horizons (30 CFR Part 701.5). The soils on the leasehold have A horizons which range in thickness between 0-1 inches and 0-4 inches, depending upon the soil. The topsoil is of insufficient quantity to salvage as a separate layer. The topsoil, suitable subsoil, and suitable unconsolidated material below the subsoil, in situations where the material is very thick, are salvaged and the mixture is treated as topsoil material. This procedure is required because of the lack of topsoil (as defined above) that is available for reclamation.

The results of laboratory and field chemical and physical analyses were used to evaluate the soils on the leasehold with regard to their suitability for use as topsoil material. The criteria used were those established by the Wyoming DEQ (1984) for topsoil and overburden. In addition to the analytical results, geobotanical studies were conducted to assess the potential for elevated selenium levels. The physical and chemical properties of the soils are presented in Appendix A.

Soils on the leasehold can be placed in one of four major soils groups. These groups are:

residual soils, procellanite-derived soils, eolian soils, and alluvial soils. Since the soils occurring in each group generally have similar characteristics, the suitability for topsoil material of each soil will be discussed on the basis of the soil group in which it occurs.

The residual soils found within the lease area are the Dulce, Travessilla, and Zyme soils. The Dulce and Travessilla soils have no chemical properties that limit suitability. High amount of surficial rock fragments (20-50 percent by volume) makes them marginally suitable to unsuitable based upon the Wyoming DEQ guidelines. Zyme soils also have high amounts of surficial rock fragments. Additionally, Zyme soils are marginally suitable due to clay content. Each of these soils is generally severely eroded, with bedrock occurring at less than six inches. Topsoil salvage of these soils would be infeasible in many cases.

The unnamed Soils A and B are the porcellanite-derived soils and are found primarily in the J-21 mining area. These soils were not sampled since the rock-fragment content throughout their profiles (35-70 percent by volume) make them unsuitable for topsoil.

The soils that formed in eolian material, Cahona, Pulpit, Sharps, and Bond are all suitable for topsoil. The Begay soils formed in eolian material mixed with alluvium. They have similar characteristics to the eolian soils and are included here for discussion. These soils have been extensively evaluated to determine suitability. Out of the ten Cahona pedons sampled, with the deepest down to 186 inches, only one horizon in one pedon was unsuitable. Sample 11-1-8 has an acid-base potential of -63.1 tons $CaCO_3$/1000 tons dry material. This sample represented ten inches out of a total 105-inch profile. The material directly above this sample, 11-1-7 has an acid-base potential of 117.0. Mixing which occurs during topsoil salvage and replacement will ameliorate any problems with these soils should thin horizons with negative ABP be encountered on a consistent basis. In the same profile, Samples 11-1-6 and 11-1-7 have marginally suitable EC levels of 10.8 and 11.5 and clay content of 3.1 and 2.2, respectively. Again, this is not typical of the Cahona profile. Mixing of materials during salvage and replacement will ameliorate these problems. Cahona soils in G11B map unit are underlain by a horizon high in rock fragments at a depth between 20 and 40 inches. They are otherwise similar to other Cahona soils above that depth. The four remaining eolian soils are suitable for topsoil based on the analytic results. One pedon of Begay soils (27-108) showed an unsuitably high SAR value (16.3) at 71 inches. This high value is anomolous for these soils.

The alluvial soils, Las Lucas, San Mateo, and Oelop, are affected by high salt and sodium levels at varying depths in the profile due to their landscape position. These soils have been extensively sampled as part of a deep-hole sampling program as well as for representative profiles because their depths make them excellent sources of great volumes of topsoil material. A summary of the deep-hole studies is presented in Appendix A, Table 12.

San Mateo soils have been sampled at ten different locations. At three of these locations, the pedons were sampled either by horizon or in two-foot increments; the remaining seven sites were sampled below ten feet in two-foot increments. Of the three pedons sampled from the surface, all of which were in Reed Valley, depth to unsuitably high EC values ranged from 8 to 16 feet. Values for SAR did not exceed suitability levels in any of these three pedons. At one location (13-14DSS), layers below 14 feet showed very low acid-base potentials.

In the remaining seven sampled pedons, four were sampled in a tributary of Dinnebito Wash in the southern part of the J-21 mining area. All of the samples from this area have good suitability for all suitability criteria, with the exception of five samples. Samples 13-2DS (20'-22' and 22.0'-22.5') and 15-23DS (20.0'-22.0') had slightly low acid-base potentials. All were between 0 and -5 tons $CaCO_3$ which, though suitable, is close to the unsuitable level. Mixing with the overlying horizons will alleviate any deleterious effects of these levels should the demand for topsoil material require their salvage. Two samples, 13-10DS (10'-12' and 12'-14'), had slightly elevated selenium levels. They are 0.11 ppm and 0.13 ppm, respectively. These levels are considered marginally suitable.

The other three sampled San Mateo pedons were located in Reed Valley Wash or a side tributary to Reed Valley Wash. Depth to unsuitable EC values occurred at ten feet in the two samples in Reed Valley Wash. At the other location (13-19DS), sampled to 18.7 feet, neither EC nor SAR levels exceeded suitability criteria. The San Mateo soils are suitable for use as topsoil material to variable depths that average 13.7 feet. Close attention will be given to the topsoil depth maps, which designate the recommended salvage depths based on the deep-hole sampling results.

Las Lucas soils have been sampled at 13 locations, five of which were sampled from the surface to bedrock. Four of these five pedons were located in tributaries to Reed Valley Wash and three show high EC and SAR values. At these three locations, the depth to unsuitabily high levels of one or more parameters ranged from 31 inches to 10 feet (at a location sampled at ten feet and below). Conductivity levels were between 12 and 20 mmhos. Site 19-67 did not exhibit any unsuitably high levels. The fifth pedon sampled from the surface downward showed high SAR values at 96 inches. The samples from the nine other locations did not show any unsuitably high levels. Las Lucas soils are, therefore, suitable for topsoil down to bedrock except in the Reed Valley area, where close attention will be given to the topsoil depth maps, which designate the recommended salvage depths.

The Oelop soil is the third soil in the alluvial soils group. It was sampled three times, each from the surface to bedrock. One location (12-231) showed unsuitably high SAR's at 12 feet and one (19-55) at 20 inches. The samples from the other site (12-259) were suitable down to 17.5 feet. Site 19-55 was in the same drainage as the Las Lucas sample that was unsuitable at 31 inches. In addition to high SAR values, both sites in this drainage have low acid-base potential below nine feet. Close attention will be given to the topsoil depth maps, which designate the recommended salvage depths.

Except for the few anomalous horizons and depth increment samples noted above, the soils identified in the Order 1 and 2 surveys are chemically suitable for use as topsoil material; providing the recommended stripping depths on Drawing 85305B, Sheets 1 through 15 are closely followed. The Dulce, Zyme, and Travessilla soils are marginally suitable or unsuitable physically based upon the Wyoming guideline because of their coarse rock fragment percentage. In many cases, the depth of these residual soils and slope steepness precludes salvage as well.

When topsoil material requirements so demand, Peabody intends to salvage the residual soils unless their depth makes salvage impractical. Mixing with much greater volumes of material that is physically suitable, which occurs in the topsoil handling process, will ameliorate the adverse characteristic of the residual soils. The benefits of the addition of small amounts of coarse rock fragments in localized areas in terms of restricting surface runoff and reducing raindrop impact and wind erosion (if rocky material should be deposited on the surface of redistributed topsoil), outweigh the liability of a potential reduction in moisture holding capacity (if it should occur at depth).

Geobotanical studies were conducted on the disturbance areas in support of the topsoil material suitability assessments. The objective of the studies was to determine the extent and distribution of soils that exhibit the potential for contributing to toxic concentrations of selenium in forage. The studies were justified on the basis of the existence of selenium accumulator plant species on the disturbance areas. A comprehensive report of the studies may be found in Appendix A.

The geobotanical studies demonstrated that selenium-accumulating plant populations are locally common in certain subhabitats in the study areas. The populations are usually distributed throughout the study areas, are generally predictable in their areas of occurrence, and are important components of the vegetation in the areas where they occur. The selenium accumulators occurred on the shallow soils associated with wooded ridges and disturbed areas, and were absent from the broad sagebrush valleys and wash terraces where the deeper soils occur.

Based upon the results of selenium analysis in plants and soils at a representative cross section of sites where accumulator plants were found, the soils in which they were found growing are not seleniferous. This conclusion was reached for several reasons. The primary selenium accumulator species did not contain unusually high concentrations of the element and known secondary accumulator plants sampled at the sites did not contain concentrations that are toxic. Secondary accumulators are known to accumulate toxic levels of selenium if present on seleniferous soils. Second, the plant available concentrations in the soils at the sites were low. One soil stratum at one site (Location 29-1) and two strata at another site (Location 22-5 and 22-6) out of 27 sites had plant-available selenium concentrations greater than 0.1. One additional stratum at another site (84-14A) exceeded the suspect concentration. This stratum was an unconsolidated gray shale encountered at a depth of 44 inches. Plant-available concentration exceeding 0.1 ppm are generally regarded as suspect for soils that have potential for use in reclamation. They are not considered unsuitable. Third, no selenium poisoning of livestock has been reported in or surrounding the leasehold.

Topsoil Material Suitability Evaluation (2000 and 2003 Soil Surveys)

Topsoil suitability and salvage depth recommendations for the 2000 and 2003 soil survey areas are based on site-specific soils and map unit data. The information is presented in Appendix A-1 and shown on Drawing 85305C (11 sheets total).

Overburden Sampling Program - Background

Peabody began an overburden-sampling program at the Black Mesa and Kayenta Mines in August of 1977. The objectives of the program have evolved based upon the need for compliance with the Surface Mining Control and Reclamation Act and pertinent regulations pursuant to the Act. Since initiation of the program, 143 deep overburden cores, 49 shallow cores, and 20 highwall cores have been drilled to characterize the geochemistry and physical properties of the overburden on the Black Mesa leasehold. Eighty-six of the deep cores and all of the shallow and highwall cores are pertinent to this permit application (Table 4). The remaining cores are located in areas that have been mined out or in areas that are not projected to be disturbed in the life-of-mine plans.

The procedures used to drill, handle, and describe the overburden cores are presented in Chapter 4. The deep cores were sampled at logical geologic intervals not to exceed ten feet in length or to a major change in lithology. Strata less than two feet in thickness, except nonmineable coals, were combined with the next logical unit where possible. Sampling intervals began at ground surface and included the stratum immediately below the lowest mineable coal seam. The highwall cores were sampled at two foot intervals to a depth of ten feet. The shallow cores were sampled at two foot intervals to a depth of thirty feet or to contact with a coal seam greater than 0.5 feet in thickness. From 1977 through 1979, drilling supervision and all geologic core descriptions were performed by staff geologists from Peabody's Corporate Office in St. Louis, Missouri. Fifty-seven cores were drilled during this time period. From 1980 to the present, all drilling supervision and geologic descriptions were performed by geologists or soil scientists from Peabody's Black Mesa and Kayenta Mines.

Overburden core locations from 1977 through 1985 were determined using a grid system that is fit to the contour of the outermost coal cropline in a given mining area. Within the confines of terrain, irregular coal croplines, and variable numbers and thicknesses of the coal seams, the deep holes were spaced approximately 2,000 feet apart. Thus, deep overburden core coverage in the mining areas is approximately one per 90 acres with the exception of the contiguous J-19, 20, 21, and 23 mining areas (Table 4).

The J-19, 20, 21, and 23 mining areas were some of the last areas to be drilled. The drilling intensity was reduced because the stratigraphy and geochemical variability, as indicated by the holes in other areas, was so great that no benefit would be derived from

TABLE 4

Summary of Overburden Sampling Intensity by Mining Area

| Mining Area | Area (Acres) | Deep Cores (No.) | Coverage (Acres/Core) | Shallow and Highwall Cores (No.) |
|---|---|---|---|---|
| J-2 | 386.0 | 1 | 386.8 | - |
| J-4 | 231.5 | 1 | 231.5 | - |
| J-6 | 747.9 | 2 | 374.0 | - |
| J-7 | 333.4 | 4 | 83.4 | - |
| J-9 | 222.5 | 1 | 222.5 | - |
| J-14 | 668.0 | 2 | 334.0 | - |
| J-15 | 340.2 | 1 | 340.2 | - |
| J-16 | 481.9 | 6 | 80.3 | - |
| J-19 through 23 | 5,022.0 | 18 | 279.0 | 64 |
| J-28 | 428.7 | 7 | 61.2 | - |
| N-6 | 2,011.0 | 18 | 111.7 | - |
| N-9 | 1,279.3 | 4 | 319.8 | - |
| N-10 | 909.1 | 4 | 227.3 | 5 |
| N-11 | 494.2 | 4 | 123.6 | - |
| N-14 | 579.8 | 6 | 96.6 | - |
| N-99 | 2,648.2 | 7 | 378.3 | - |

drilling at 90-acre centers. Also, Peabody's plan for handling selected overburdens does not require complete lateral and vertical determination of unsuitable overburdens. Rather, the plan is designed to identify zones of near-surface overburden that can be used as topsoil material supplements should toxic or potentially toxic forming spoils that require burial be identified following grading. Sixty-five additional shallow and highwall cores were drilled in the J-19, 20, 21, and 23 areas, and five additional shallow cores were drilled in the N-10 mining area to supplement the deep overburden core data. Peabody's plan for insuring that unsuitable overburden will not affect plant growth in the postmining landscape is presented in Chapter 22. Twenty-one deep core holes were drilled in the remaining unmined life-of-mine coal resource areas in 2003. The OSM-approved drill hole density was two core holes per section (Gavette-OSM June 25, 2003 letter to Dunfee-PWCC). This density was justified because coal seams in the new areas are identical to those currently being recovered so overburdens are expected to be similar to those previously encountered and characterized. The locations of the overburden core holes are shown on Drawings 85613 and 85613A.

Overburden Analytical Assessment Procedures

Descriptions and references for the analytical procedures used on the overburden samples are presented in Attachment 2. The analytical methods, including field, laboratory, and quality control procedures for the 2003 sampling episode are those described in Chapter 22, Table 18. Different parameter suites have been analyzed on different sets of cores depending upon: (1) whether or not they were shallow, highwall, or deep cores; or (2) when they were drilled relative to the status of negotiations with the regulatory authority regarding the necessary parameters needed for characterization. The different suites used are presented in Table 5. A summary of suites used on the cores in each mining area, and in several cases on individual cores, is presented in Table 6. The majority of the cores drilled prior to 1984 were originally analyzed using Suite 1 only. These cores were reanalyzed in 1985 for additional parameters. The results of the analyses and associated lithologic descriptions are presented in Appendix B.

An assessment of the deep core data was performed to estimate the characteristics of the regraded spoil and to identify those parameters that must be considered in planning mined soil reconstruction. The assessment was performed at two levels of intensity. First, the data were inspected to determine the parameters that could realistically contribute to potentially unsuitable spoils and minesoils. A detailed assessment of the parameters so

TABLE 5

Parameter Suites Used on the Overburden Cores[1]

| Suite 1 | Suite 2 | Suite 3 | Suite 4 | Suite 5 | Suite 6[2] | Suite 7 |
|---|---|---|---|---|---|---|
| pH | B | Cl | S (pyritic) | pH | pH | pH |
| E.C. | As | F | | Saturation % | E.C. | E.C. |
| Saturation % | Se (Sol.) | $CO_3$ | | E.C. | Na | Na |
| Na | Mo | $HCO_3$ | | Na | Ca | Ca |
| Ca | Hg | $SO_4$ | | Ca | Mg | Mg |
| Mg | Co | | | Mg | SAR | SAR |
| SAR | Cu | | | SAR | ESP | S (total) |
| ESP | Fe | | | ESP | S (total) | S (pyritic) |
| P | Mn | | | S (total) | S (pyritic) | CaCO3 equiv. |
| K | Zn | | | $CaCO_3$ | $CaCO_3$ | Particle Size |
| N | | | | Particle Size | Particle Size | B |
| S (total) | | | | B | Se (total) | Se (sol.) |
| $CaCO_3$ equiv. | | | | Se (sol.) | | Se (total) |
| Particle Size | | | | | | |
| Moisture % | | | | | | |
| Org. Mat. | | | | | | |

[1] Suites 1 through 4 pertain to the 1977-1985 deep cores, Suite 5 was run on the highwall cores, Suite 6 was run on the shallow cores, and Suite 7 was used for the 2003 deep cores.

[2] Total Selenium analysis was run on selected cores.

TABLE 6

Summary of the Parameters Analyzed on the

Overburden Cores by Mining Area

| Mining Area | Core Type | Parameter Suites (Table 5) and Exceptions |
|---|---|---|
| J-7 | deep | - Suites 1 and 2 on all |
| J-16 | deep | - Suites 1 and 2 on all |
| | | - Suite 4 on Core 26462C only |
| J-19 through 23 | deep | - Suite 1 except N,P,K, % Moist., and Org. Mat. on all |
| | | - Suite 2 except B, Se, Hg, Zn |
| | | - Suites 1, 2 and 3 on Cores 24292C and 24589C only |
| | | - Suite 7 on Core 30365EO only |
| | shallow | - Suite 6 on all |
| | highwall | - Suite 5 on all |
| N-6, J-28 | deep | - Suite 1 on all |
| N-10 | deep | - Suite 1 on all except Core 30354EO where Suite 7 was used |
| | shallow | - Suite 6 on all |
| N-11 | deep | - Suites 1, 2, 3, 4 except N,P,K, % Moist., Org. Mat., B, and Se on all |
| N-14 | deep | - Suite 1 on Core 20268C only |
| | | - Suite 1 and 2 on Core 20257C only |
| | | - Suites 1, 2 and 3 except B and Se on Core 20346C only |
| | | - Suites 1, 2, 3 and 4 except B and Se on Core 20259C only |
| | | - Suites 1, 2 3 and 4 except N,P,K, % Moist., Org. Mat., B and Se on Cores 26269C and 26271C only |
| J-2, J-4, J-6, J-9, J-14, J-15, N-9, N-99 | deep | - Suite 7 |



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identified was then made. The diagnostic criteria and suitability limits, except for selenium, were taken from the Criteria for Evaluation of Overburden and Regraded Spoils in Attachment 3 (Office of Surface Mining Draft Guideline, unpublished). The Wyoming DEQ guideline was used for selenium (Volume II, Appendix A, Page 24). The 2003 deep core data was assessed using criteria presented in Chapter 22, Table 17.

The percentage of the total core volume manifested by an unsuitable parameter was calculated as part of the detailed assessment. The parameters and suitability limits used for the 1977 to 1985 core data were: (1) pH less than 5.5 and pH greater than 8.8; (2) electrical conductivity (E.C.) greater than 12.0 mmho/cm; (3) sodium absorption ratio (SAR) greater than 18 or 22, depending upon texture; (4) acid-base accounts ($CaCO_3$ equivalence based on total sulfur) less than zero; and (5) clay content greater than 50 percent or both clay and silt content greater than 40 percent. The functional portion of each core, minus mineable coal and topsoil, down to the lowest mineable seam was used to perform the calculations. For interpretive purposes, parameters with unsuitable levels representing more than five percent of the total core volume were considered possible contributors to unsuitable or suspect spoils. Levels representing more than 15 percent of the total core volume were considered probable contributors to unsuitable or suspect spoils. In addition, weighted mean SAR's and negative and positive acid-base accounts were calculated based upon the thickness of each stratum in a particular core.

The shallow and highwall cores were assessed using the Criteria for Evaluation of Topsoil and Topsoil Substitutes in Attachment 3 (Office of Surface Mining Draft Guideline, unpublished) except for selenium. The Wyoming DEQ guideline for plant-available selenium contained in Volume II, Appendix A, Page 24 was used for samples analyzed for soluble selenium (highwall cores). The New Mexico guideline for total selenium (greater than 0.5 ppm), that is identical to OSMRE's criteria for Evaluation of Overburden and Regraded Spoils was utilized to interpret the results of analyses for total selenium on selected shallow cores. The New Mexico soil and soil substitute suitability rating guidelines are presented in Attachment 3.

Overburden Assessment (1977-1985 Core Data)

A cursory inspection of the cores indicates that unsuitable strata, with regard to one or more parameters, exist in most cores (Appendix B). However, the geochemistry and stratigraphic sequence of the overburden exhibits such extreme variability that the lateral and vertical extent of unsuitable or suspect strata cannot be correlated within or between mining areas. The primary chemical attributes that could contribute to unsuitable spoils and minesoils are elevated SAR's (potential for sodic zones), negative acid-base accounts (potential for acid-forming zones), acid pH values, and suspect selenium concentrations (potential for selenium enriched zones) in the N-10 mining area. These strata are typically located at moderate to considerable depth or are associated with the coal seams. The near surface overburden is generally of much better quality.

Inspection of the cores for which trace element analysis is available does not indicate consistent levels of any suspect trace elements, with the possible exception of selenium, which could potentially contribute to phytotoxicity or animal toxicity. However, this statement must be qualified to the extent that toxicity levels are questionable or do not exist for most of the trace elements and suspect concentrations may or may not have any adverse effects depending on a variety of other factors.

One core in the J-1/N-6 mining area (Core No. 23165C) had strata that exhibited an unsuitable boron concentration that was greater than five percent of the total core volume. The percentage was 6.2 percent. The boron concentration was 5.7 ppm. None of the remaining cores in the J-1/N-6 mining area or in any other mining area exhibited percentages exceeding five percent. The Black Mesa overburden will not contribute phytotoxic concentrations of boron to graded spoils.

The detailed assessment of the remaining parameters of concern in the Black Mesa overburden are summarized in Table 7. Electrical conductivity and clay content are included for demonstration purposes and to aid in the interpretation of the other parameters. The clay content of the Black Mesa overburden will not contribute to undesirably heavy minesoils. Electrical conductivities are well within the suitable limits in the majority of cores.

Soluble selenium concentrations in strata from several of the deep cores on which the analysis was performed exceeded the suspect level of 0.1 ppm that is recommended by the Wyoming DEQ (Table 7). Analysis for plant available forms of selenium are not normally recommended for deep overburden because of the reducing environment. However, it was judged to be the appropriate method for the cores on which it was run because the samples have been stored in the laboratory for extended periods of time. Oxidation has undoubtedly occurred. All cores applicable to the J-7 mining area had strata that

TABLE 7

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | | SAR | $CaCO_3$ equiv. | | | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ | % >0.1 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **J-7 Mining Area:** | | | | | | | | | | | |
| 15418-C | 1.9 | 0.0 | 0.0 | .07 | 6.1 | 60.3 | 19.4 | 10.6 | 2.7 | 20.5 | 0.0 |
| 23154-C | 26.3 | 9.1 | 0.0 | 0.12 | 25.2 | 47.3 | 14.5 | 0.0 | | Not Calculated | 2.8 |
| 23156-C | 0.0 | 0.0 | 25.1 | 0.11 | 21.0 | 80.9 | 23.0 | 16.2 | 0.2 | 30.8 | 6.7 |
| 23158-C | 0.0 | 14.5 | 0.0 | 0.10 | 8.3 | 47.4 | 11.3 | 20.9 | 2.3 | 16.3 | 3.2 |
| **J-16 Mining Area:** | | | | | | | | | | | |
| 23146-C | 1.5 | 22.1 | 0.0 | 0.05 | 0.0 | 37.3 | 16.5 | 51.2 | 15.3 | 19.0 | 13.0 |
| 23147-C | 11.9 | 26.5 | 0.0 | 0.05 | 5.0 | 36.4 | 16.3 | 31.0 | 14.1 | 20.3 | 12.3 |
| 23148-C | 0.0 | 9.8 | 0.0 | 0.04 | 7.8 | 65.8 | 25.3 | 46.5 | 16.6 | 23.1 | 12.4 |
| 23325-C | 8.1 | 12.8 | 0.0 | 0.08 | 21.6 | 36.6 | 12.8 | 37.9 | 5.3 | 24.1 | 16.3 |
| 23328-C | 24.4 | 9.2 | 1.8 | 0.09 | 23.1 | 68.0 | 23.5 | 36.7 | 16.1 | 28.0 | 5.8 |
| 26462-C | 45.6 | 7.4 | 0.0 | - | | 48.3 | 24.4 | 1.6 | 0.1 | 29.0 | 0.0 |

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | SAR | | $CaCO_3$ equiv. | | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ % >0.1 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **J-19 through 23 Mining Areas:** | | | | | | | | | | |
| 24403-C | 0.0 | 0.0 | 0.0 | - | 23.4 | 12.1 | 13.0 | 3.0 | 79.2 | 0.0 |
| 24404-C | 6.4 | 0.0 | 0.0 | - | 52.6 | 20.7 | 5.0 | 0.1 | 70.3 | 0.0 |
| 24405-C | 0.0 | 0.0 | 0.0 | - | 41.4 | 16.9 | 10.3 | 0.9 | 50.9 | 0.0 |
| 24406-C | 43.8 | 0.0 | 0.0 | - | 62.1 | 17.7 | 30.1 | 1.5 | 26.7 | 21.1 |
| 24407-C | 21.4 | 0.0 | 0.0 | - | 73.9 | 26.1 | 30.9 | 5.4 | 23.7 | 8.0 |
| 24408-C | 42.5 | 4.3 | 0.0 | - | 34.8 | 11.5 | 13.6 | 1.0 | 30.6 | 23.5 |
| 24412-C | 23.1 | 5.1 | 0.0 | - | 53.2 | 19.6 | 13.4 | 4.3 | 28.9 | 5.1 |
| 24413-C | 19.9 | 8.0 | 0.0 | - | 70.0 | 19.9 | 23.0 | 2.7 | 30.4 | 12.4 |
| 24415-C | 39.7 | 3.3 | 0.0 | - | 80.8 | 26.1 | 14.8 | 2.2 | 41.7 | 16.7 |
| 24416-C | 2.9 | 0.0 | 0.0 | - | 38.8 | 16.2 | 15.4 | 3.0 | 30.9 | 4.9 |
| 24417-C | 36.2 | 7.9 | 0.0 | - | 33.2 | 15.7 | 20.8 | 1.5 | 21.4 | 10.8 |
| 24418-C | 26.8 | 0.0 | 0.0 | - | 59.1 | 22.2 | 24.7 | 4.0 | 23.4 | 1.3 |
| 24419-C | 0.0 | 0.0 | 0.0 | - | 6.2 | 7.6 | 7.4 | 0.2 | 47.1 | 0.0 |
| 24420-C | 0.0 | 0.0 | 0.0 | - | 46.4 | 21.7 | 38.5 | 8.4 | 14.3 | 0.0 |

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | | SAR | | CaCO$_3$ equiv. | | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ | % >0.1 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **J-19 through 23 Mining Areas (Cont.):** | | | | | | | | | | | |
| 24423-C | 25.3 | 0.0 | 0.0 | - | | 71.1 | 21.3 | 10.9 | 2.8 | 29.7 | 5.5 |
| 24292-C | 0.0 | 0.0 | 0.0 | 0.04 | 0.0 | 36.9 | 16.7 | 18.1 | 5.7 | 65.1 | 0.0 |
| 24589-C | 0.0 | 0.0 | 0.0 | 0.06 | 2.9 | 75.8 | 27.6 | 18.8 | 2.6 | 21.8 | 13.3 |
| **N-6 Mining Area:** | | | | | | | | | | | |
| 21104-C | 0.0 | 9.9 | 0.0 | 0.06 | 10.9 | 35.4 | 13.0 | 10.6 | 2.7 | 36.9 | 5.0 |
| 23160-C | 0.0 | 5.5 | 0.0 | 0.07 | 13.2 | 18.2 | 7.8 | 19.7 | 1.5 | 19.7 | 1.6 |
| 23161-C | 28.3 | 0.0 | 0.0 | 0.03 | 3.5 | 38.2 | 15.6 | 2.6 | 0.3 | 28.9 | 10.9 |
| 23162-C | 0.0 | 0.0 | 0.0 | 0.07 | 5.2 | 49.9 | 17.7 | 4.4 | 0.5 | 42.5 | 0.0 |
| 23163-C | 0.0 | 7.8 | 0.0 | 0.13 | 34.3 | 47.1 | 13.6 | 7.4 | 0.8 | 44.4 | 25.3 |
| 23164-C | 0.0 | 9.8 | 0.0 | 0.09 | 23.1 | 52.8 | 16.0 | 13.3 | 0.4 | 30.7 | 0.0 |
| 23165-C | 0.0 | 9.5 | 0.0 | 0.10 | 27.7 | 61.5 | 18.6 | 22.9 | 2.0 | 30.0 | 16.0 |
| 23166-C | 9.2 | 6.8 | 0.0 | 0.09 | 26.0 | 19.4 | 7.4 | 6.2 | 0.8 | 58.4 | 31.5 |
| 24093-C | 19.0 | 2.4 | 0.0 | 0.14 | 34.2 | 61.3 | 20.4 | 7.1 | 1.1 | 42.9 | 7.1 |

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | | SAR | | $CaCO_3$ equiv. | | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ | % >0.1 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **N-6 Mining Area (Cont.):** | | | | | | | | | | | |
| 24094-C | 0.0 | 1.4 | 0.0 | 0.06 | 8.6 | 41.2 | 19.5 | 22.7 | 1.8 | 53.1 | 6.9 |
| 24095-C | 33.2 | 0.0 | 0.0 | 0.06 | 7.6 | 81.7 | 29.5 | 8.4 | 1.2 | 45.9 | 18.3 |
| 24096-C | 0.0 | 0.0 | 0.0 | 0.10 | 29.9 | 79.6 | 25.4 | 7.4 | 0.5 | 51.0 | 0.0 |
| 24097-C | 9.2 | 5.0 | 0.0 | 0.11 | 30.1 | 90.6 | 28.3 | 16.0 | 0.3 | 37.9 | 17.2 |
| 24098-C | 20.9 | 16.2 | 0.0 | 0.05 | 5.4 | 44.6 | 15.5 | 22.6 | 3.7 | 36.4 | 2.7 |
| 24099-C | 23.8 | 4.1 | 0.0 | 0.08 | 15.0 | 47.2 | 19.7 | 15.6 | 1.0 | 19.0 | 14.5 |
| 24400-C | 0.0 | 0.0 | 0.0 | 0.09 | 18.4 | 12.1 | 11.9 | 5.6 | 4.1 | 56.8 | 0.0 |
| 24401-C | 0.0 | 0.0 | 0.0 | 0.07 | 12.7 | 0.0 | - | 17.8 | 1.6 | 15.4 | 8.3 |
| 24402-C | 0.0 | 2.8 | 0.0 | 0.04 | 10.4 | 21.9 | 7.4 | 27.7 | 4.8 | 21.6 | 6.0 |
| **N-10 Mining Area:** | | | | | | | | | | | |
| 21099-C | 0.0 | 33.6 | 0.0 | - | | 5.2 | 4.0 | 54.7 | 15.2 | 12.3 | 4.6 |
| 21100-C | 0.0 | 35.9 | 4.9 | - | | 6.6 | 4.3 | 44.1 | 18.1 | 19.8 | 12.4 |
| 21101-C | 0.0 | 37.7 | 3.4 | - | | 6.8 | 3.5 | 36.6 | 14.4 | 17.2 | 0.0 |

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | SAR | | | $CaCO_3$ equiv. | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ % >0.26 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **J-28 Mining Area:** | | | | | | | | | | |
| 23155-C | 1.9 | 6.4 | 0.0 | - | 20.1 | 5.0 | 10.7 | 0.2 | 11.0 | 6.8 |
| 23329-C | 0.0 | 0.0 | 0.0 | - | 37.1 | 13.1 | 2.5 | 0.1 | 11.9 | 17.1 |
| 23330-C | 0.0 | 0.0 | 15.2 | - | 21.1 | 4.5 | 0.0 | 0.0 | 10.1 | 21.1 |
| 23331-C | 17.0 | 3.9 | 0.0 | - | 11.0 | 2.8 | 8.4 | 0.1 | 7.4 | 20.4 |
| 23332-C | 7.4 | 7.9 | 0.0 | - | 8.1 | 2.6 | 14.8 | 0.2 | 6.4 | 2.2 |
| 23333-C | 0.0 | 15.2 | 13.8 | - | 4.4 | 1.2 | 12.3 | 0.2 | 7.1 | 17.9 |
| 23334-C | 0.0 | 4.9 | 0.0 | - | 7.8 | 3.3 | 4.9 | 0.1 | 12.8 | 22.2 |

TABLE 7 (Cont.)

Evaluation of Overburden Suitability

In the Mining Areas[1,2]

| Overburden | pH | | E.C. (mmho/cm) | Se (ppm) | | SAR | | | $CaCO_3$ equiv. | | Clay Content |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % >8.8 | % <5.5 | % >12.0 | $\bar{x}_w$ | % >0.1 | % unsuit. | $\bar{x}_w$ | % neg. | $\bar{x}_w$ (neg.) | $\bar{x}_w$ (pos.) | % unsuit. |
| **N-11 Mining Area:** | | | | | | | | | | | |
| 6272-C | 14.5 | 2.1 | 0.0 | - | | 66.2 | 37.5 | 33.9 | 6.2 | 29.9 | 0.0 |
| 26364-C | 0.0 | 4.1 | 0.0 | - | | 43.6 | 23.3 | 30.9 | 9.1 | 38.7 | 3.7 |
| 26367-C | 9.7 | 16.3 | 0.0 | - | | 27.5 | 16.9 | 24.2 | 7.2 | 58.1 | 0.0 |
| 26463-C | 0.0 | 5.7 | 0.0 | - | | 28.4 | 12.9 | 44.4 | 12.6 | 52.3 | 0.0 |
| **N-14 Mining Area:** | | | | | | | | | | | |
| 20257-C | 0.0 | 26.2 | 0.0 | 0.07 | 15.1 | 36.9 | 11.8 | 26.2 | 8.9 | 34.7 | 11.4 |
| 20259-C | 28.0 | 5.9 | 0.0 | - | | 42.1 | 16.4 | 33.7 | 2.8 | 13.7 | 16.6 |
| 20268-C | 0.0 | 29.9 | 0.0 | - | | 36.4 | 13.4 | 22.6 | 5.8 | 12.8 | 11.2 |
| 20346-C | 0.0 | 29.3 | 3.4 | - | | 7.6 | 4.5 | 41.6 | 12.5 | 14.8 | 6.7 |
| 26269-C | 9.3 | 9.9 | 0.0 | - | | 32.4 | 15.6 | 34.6 | 10.7 | 21.6 | 12.4 |
| 26271-C | 24.3 | 11.9 | 0.0 | - | | 39.2 | 19.7 | 37.1 | 10.9 | 12.4 | 10.1 |

[1]The percent of core with an unsuitable parameter = $\frac{\text{(depth intervals with unsuitable parameter values)x100}}{\text{total core interval (adjusted)*}}$

[2]Weighted average ( $\bar{x}_w$) = $\frac{\text{(depth intervals with unsuitable parameter values x parameter value)}}{\text{total core interval (adjusted)*}}$

*Adjusted total core depth (minus probable topsoil and mineable coal depths)

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exhibited suspect selenium concentrations which were greater than five percent of the total core volumes. The percentages ranged from 6.1 to 25.2 percent. Selenium concentrations ranged from less than 0.01 ppm to 0.98 ppm. The one core for which selenium data is available for the N-14 mining area had a percentage of total core volume greater than five percent and a range in selenium concentrations from less than 0.01 ppm to 0.34 ppm. The remaining mine areas showed a similar pattern. Most cores had percentages greater than five. Selenium concentrations ranged from very low to 0.81 ppm. The 0.98 ppm value at J-7 was the greatest concentration detected. Most values exceeding the suspect level were less than 0.3 ppm.

The results indicate the probability of suspect concentrations of plant-available selenium occurring in regraded spoils. Emphasis must be placed on the term suspect, however, because the evaluation of the potential for selenium problems, like most other trace elements, is complicated by a host of factors. Concentrations of selenium in plant growth media that could contribute toxic levels in vegetation depend upon the plant species occurring on a given site, precipitation, the various forms of the element that are present and the related physical and chemical characteristics of the minesoil. Also, the amount of selenium ingestion by livestock must be considered. Acute toxicity results from the ingestion of lethal amounts of plants containing high levels of selenium (several hundred ppm). Acute poisonings are uncommon because the plant species that are capable of accumulating these concentrations are not palatable. Chronic intoxication, whether it be blind staggers or alkali disease, requires the consumption of moderate concentrations of selenium (5 to 50 ppm) over a considerable length of time. This would imply that selenium concentrations in the soil that are sufficiently great to cause toxic concentrations in forage must occur over extensive areas to enable grazing animals to ingest toxic concentrations. Because of the lack of definition of the many variables that surround the selenium issue, it is difficult to accurately assess the potential for unsuitable spoils on the Black Mesa leasehold. Nevertheless, the selenium concentrations in the overburden are suspect, and will be considered in mined soil reconstruction.

The percent of total core volume and weighted mean SAR's (Table 7) indicates that the potential exists for sodic zones to occur at or near the surface of regraded spoils. The weighted mean values and clay content of the cores indicates that the sodicity problems will be moderate, but should be considered in minesoil reconstruction, except at the N-10 mining area. The core data at this mining area does not indicate any potential for sodicity problems.

The percent of total core volumes that have negative $CaCO_3$ equivalence (Table 7) indicates that acid or acid-forming spoils can be anticipated in most areas. Eighty-eight percent of the cores have percentages of negative equivalence that are greater than five, and 57 percent have total percentages greater than 15. The problem of acidity will not be as bad as the percentages indicate because of the excess alkalinity in many of the cores. For example, three of the four cores applicable to the J-7 mining area have percentages greater than five, but the proportion of negative to positive acid-base accounting favors an alkaline environment.

Twenty shallow cores, designated as the highwall cores, were drilled on the J-21 mining area highwall to characterize the near surface overburden. The cores were drilled to a depth of ten feet and sampled at two-foot intervals. The laboratory results are presented in Appendix B. The core data was first assessed in terms of the suitable category for topsoil and topsoil supplements. Five percent, or one core (Core No. 11EO) was suitable throughout. Marginally suitable or unsuitable material was encountered at the second sampling interval in ten percent of the cores (Core Nos. 16EO and 20EO). Marginally suitable or unsuitable material was encountered at the third sampling interval (below four feet) in fifteen percent of the cores (Core Nos. 15EO, 17EO and 21EO). Marginally suitable material or unsuitable material was encountered at the first sampling interval (surface) in the remaining 70 percent of the cores. The parameters that failed the suitable category criteria were texture (sand or clay content) and pH (less than 5.5 or greater than or equal to 8.4).

The highwall cores were then assessed in terms of the marginally suitable category for topsoil and topsoil supplements. Unsuitable material was encountered at the first sampling interval in ten percent of the cores (Nos. 5EO and 10EO). Cores 13EO and 16EO were marginally suitable to a depth of two feet. Ten percent were marginally suitable to four feet (Core Nos. 17EO and 20EO) and another ten percent were marginally suitable to eight feet (Core Nos. 18EO and 21EO). The remaining 60 percent of the cores were marginally suitable throughout the entire 10-foot increment.

Forty-four additional shallow cores were drilled throughout the contiguous J-19 through 23 mining area to further characterize the near surface overburden (Appendix B). The cores were drilled to a depth of 30 feet or to coal. Thirty-one of the cores were not suitable at the first two-foot sampling interval. The texture (sand or clay content) and pH (acidic or alkaline) were the predominant parameters that were out of range. The depth of suitable material in the remaining cores ranged between 2 and 14 feet with a mean suitable depth of 5.1 feet. Six of the cores were marginally unsuitable at the first sampling interval. Negative calcium carbonate equivalence, pH less than 5.5 and texture (clay content greater than 50 percent) were the parameters that went out of range. The depth of marginally suitable material in the remaining cores ranged between 2 and 30 feet with a mean depth of 13.4 feet.

Five shallow cores were drilled in the N-10 mining area to aid in the characterization of the near surface overburden (Appendix B). The cores were drilled to a depth of 30 feet or to coal. Three cores were not suitable at the first sampling interval due to pH (Core No. 26530C), sand content (Core No. 26531C), and selenium (Core No. 26533C). The depth of suitable material in the remaining two cores ranged between two and four feet with a mean suitable depth of three feet. The depth of marginally suitable material in the five cores ranged between 0 and 8 feet with a mean depth of 2.8 feet.

The data collected for the highwall and shallow cores, coupled with assessment of the quality of near-surface overburden in the deep cores, indicates that a considerable volume of topsoil supplements is available in each mining area. This material is an excellent source of supplemental material if demand so requires. The assessment of the deep overburden cores, which identified toxic or potentially toxic strata, indicates that the supplemental material may be needed to bury unsuitable zones of graded spoil.

<u>Overburden Assessment (2003 Core Data)</u>

The purpose of the 2003 overburden study was to augment the existing characterization of the geology in the permit area and proposed future life-of-mine permit areas in sufficient detail to identify acid- and toxic-forming materials and topsoil supplements/substitutes. Overburden analyses were performed by Green Analytical Laboratories, Inc. (GAL) in Durango, Colorado and Energy Laboratories, Inc. (EL) in Helena, Montana. Duplicate analyses were also completed by GAL and EL on about 10 percent of the samples collected. The analytical data for the 21 core holes is contained in Appendix B along with the lithologic descriptions and the data is summarized in Table 8.

The 2003 overburden quality is very similar to the overburdens previously encountered and characterized from mined areas or areas currently being mined and to regraded spoil quality. A cursory inspection of the cores indicates that unsuitable strata, with regard

Table 8
Evaluation of Overburden Suitability in the Mining Areas[1,2]
(2003 Core Data)

| Overburden | pH | | E.C. (mmho/cm) | Tot Se (ppm) | | Sol Se (ppm) | | Boron (ppm) | | SAR | | Acid Base Potential | | | Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No. | % > 8.8 | % < 5.5 | % > 12 | avg | % > 2.5 | avg | % > 0.26 | avg | % > 10 | avg | % unsuit. | % neg. | avg (neg.) | avg (pos.) | % unsuit. |
| J02 Mining Area: | | | | | | | | | | | | | | | |
| 30362EO | 8.3 | 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28.5 | 47.0 | 13.7 | -10.3 | 31.0 | 0 |
| J04 Mining Area: | | | | | | | | | | | | | | | |
| 30359EO | 0 | 8.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32.1 | 17.3 | 20.2 | -22.1 | 29.4 | 12.1 |
| J06 Mining Area: | | | | | | | | | | | | | | | |
| 30366EO | 21.4 | 12.6 | 13.5 | 3.7 | 2.4 | 0.3 | 3.7 | 0 | 0 | 29.2 | 40.4 | 22.3 | -16.8 | 22.7 | 5.8 |
| 30367EO | 23.7 | 12.1 | 12.1 | 3.1 | 4.0 | 0.5 | 7.6 | 0 | 0 | 29.2 | 67.7 | 36.4 | -13.0 | 26.0 | 14.9 |
| J09 Mining Area: | | | | | | | | | | | | | | | |
| 30364EO | 25.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24.0 | 25.9 | 7.6 | -19.5 | 31.2 | 0 |
| J14 Mining Area: | | | | | | | | | | | | | | | |
| 30360EO | 26.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27.4 | 33.9 | 8.3 | -3.7 | 41.1 | 8.0 |
| 30361EO | 43.2 | 16.7 | 4.1 | 0 | 0 | 0 | 0 | 0 | 0 | 39.9 | 54.8 | 21.9 | -6.8 | 30.3 | 0 |
| J15 Mining Area: | | | | | | | | | | | | | | | |
| 30363EO | 7.4 | 0 | 0 | 3.3 | 2.3 | 0 | 0 | 0 | 0 | 40.8 | 82.9 | 12.0 | -8.2 | 40.9 | 0 |
| J23 Mining Area: | | | | | | | | | | | | | | | |
| 30365EO | 0 | 1.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28.6 | 63.0 | 13.0 | -17.4 | 49.9 | 0 |
| N09 Mining Area: | | | | | | | | | | | | | | | |
| 30355EO | 19.4 | 0 | 0 | 4.4 | 1.3 | 0 | 0 | 0 | 0 | 37.9 | 75.9 | 29.6 | -32.6 | 63.6 | 1.2 |
| 30356EO | 0 | 1.5 | 0 | 2.7 | 2.2 | 0 | 0 | 0 | 0 | 32.6 | 37.7 | 54.6 | -24.9 | 28.6 | 6.8 |
| 30357EO | 1.0 | 0.6 | 0 | 2.7 | 0.5 | 0 | 0 | 0 | 0 | 45.6 | 27.6 | 34.3 | -35.0 | 53.3 | 0 |
| 30358EO | 10.2 | 0 | 0 | 0 | 0 | 0.3 | 0.9 | 0 | 0 | 38.4 | 55.0 | 32.1 | -33.5 | 97.2 | 0 |
| N10 Mining Area: | | | | | | | | | | | | | | | |
| 30354EO | 0 | 6.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32.0 | 39.8 | 12.3 | -31.2 | 36.5 | 2.1 |
| N12 Mining Area: | | | | | | | | | | | | | | | |
| 30370EO | 8.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42.3 | 58.5 | 17.2 | -31.6 | 28.3 | 0.8 |
| N99 Mining Area: | | | | | | | | | | | | | | | |
| 30351EO | 1.1 | 5.2 | 0 | 10.4 | 1.6 | 0 | 0 | 0 | 0 | 37.9 | 45.7 | 11.1 | -27.6 | 31.0 | 9.9 |
| 30352EO | 11.2 | 4.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35.9 | 50.2 | 32.0 | -20.7 | 30.8 | 3.1 |
| 30353EO | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32.1 | 24.1 | 18.9 | -23.4 | 29.6 | 1.6 |
| 30368EO | 3.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31.4 | 42.9 | 28.1 | -30.0 | 37.9 | 0 |
| 30369EO | 22.3 | 2.9 | 0 | 2.6 | 1.4 | 0.4 | 0.8 | 0 | 0 | 33.2 | 54.0 | 32.5 | -37.3 | 30.4 | 3.9 |
| 30381EO | 0 | 3.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33.3 | 31.9 | 26.6 | -27.7 | 51.9 | 0 |

[1]The percent of core with an unsuitable parameter = $\frac{\Sigma(\text{depth intervals with unsuitable parameter values})}{\text{total core interval (adjusted)*}} \times 100$

[2]Weighted average (avg) = $\frac{\Sigma(\text{depth intervals with unsuitable parameter values} \times \text{parameter value})}{\text{total core interval (adjusted)*}}$

*Adjusted total core depth (minus mineable coal depths)

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to one or more parameters, exist in all cores (Appendix B). The primary chemical attributes that will likely contribute to unsuitable spoils and minesoils are elevated SARs, negative acid-base accounts, and alkaline pH values. These strata are typically located at moderate to considerable depth or are associated with the coal seams. The near surface overburden is generally of much better quality (Chapter 22, Tables 1 and 2).

All cores exhibited suitable boron levels (Table 8). Unsuitable total selenium, soluble selenium, salinity, clay, and acid pH values almost always comprised less than five percent of the total core volume. Exceptions included the salinity at Sites 30366EO and 30367EO, the soluble selenium at Site 30367EO, the acid pH at Sites 30351EO, 30354EO, 30359EO, 30361EO, 30366EO, and 30367EO, and the clay percentage at Sites 30351EO, 30356EO, 30359EO, 30360EO, 30366EO, and 30367EO where the percentage of unsuitable material ranged between 5 and 15 percent. Based on the above data, boron, selenium, salinity, acid pH, and clay will typically not contribute to unsuitable or suspect spoils. This is in concert with the existing spoil sampling program from the areas currently being mined and reclaimed.

Unsuitable levels representing more than 15 percent of the total core volume will likely contribute to unsuitable or suspect spoils. The percent of total unsuitable core volume and weighted mean SAR's (Table 8) indicate the potential exists for sodic zones to occur at or near the surface of regraded spoils. One hundred percent of the cores have unsuitable SAR values comprising more than 15 percent of the total core volume. Soil and overburden materials with unsuitable SAR values often have associated unsuitable alkaline pH values. Sixty percent of the cores have unsuitable alkaline pH values that are greater than five, and 33 percent have total percentages greater than 15. The percent of total core volumes that have negative CaCO3 equivalence (Table 8) indicate acid or acid-forming spoils can be anticipated in most areas. One hundred percent of the cores have percentages of negative equivalence that are greater than five and 66 percent have total percentages greater than 15. However, the problem of acidity will not be as severe as the percentages indicate because of the excess alkalinity in most of the cores.

SAR and negative acid-base potential values are the two parameters most often detected as being unsuitable in final graded spoil at existing mining and reclamation areas. Over the past five years, these parameters have been detected at unsuitable levels in about 10 percent of the total samples collected and analyzed. However, suitable mitigative overburden materials are available in sufficient quantities in all existing and proposed mining areas to reclaim these sites wherever unsuitable spoil is detected in regraded spoil based on the volumes of suitable near-surface overburden material that has been identified (Chapter 22, Tables 1 and 2).

Quality Control and Duplicate Samples (2003 Core Data). Quality control is an important part of the overburden-sampling program. GAL and EL completed duplicate analyses on about 10 percent of the total samples. These analyses were completed to determine the comparability between the two laboratories since both were used for core analyses. Duplicate overburden sample data for GAL and EL are presented in Table 9. Duplicate data between GAL and EL for all parameters is statistically valid, comparable, and correlated with a high degree of significance. Although boron values between labs varied considerably, a good correlation still existed and no values were determined to be unsuitable. The difference in boron values between labs is likely attributable to slightly variable laboratory techniques.

Table 9. Duplicate Core Sample Results for Black Mesa and Kayenta Mines
Analyzed by Green Analytical Lab (GAL) in Durango, Colorado and Energy Lab (EL) in Helena, Montana (1)
2003

| SITE NO. | DEPTH (FEET) | DATE | pH-GAL | pH-EL | EC-GAL (mmhos/cm) | EC-EL | SAR-GAL | SAR-EL | Clay-GAL % | Clay-EL % | ABP-GAL (2) | ABP-EL (2) | ABPP-GAL (2) | ABPP-EL (2) | Set-GAL (ppm) | Set-EL (ppm) | Ses-GAL (ppm) | Ses-EL (ppm) | Bhws-GAL (ppm) | Bhws-EL (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30351EO | 040.0-053.0 | 07/10/03 | 7.4 | 7.7 | 0.4 | 1.9 | 1.3 | 1.3 | 12 | 18 | 4.3 | 10.2 | - - | - - | 0.1 | 0.1 | 0.01 | 0.01 | 0.81 | 0.29 |
| 30351EO | 117.6-127.5 | 07/10/03 | 6.2 | 6.2 | 3.7 | 4.2 | 3.4 | 3.4 | 21 | 29 | -40.8 | -33.8 | -25.0 | -22.1 | 0.7 | 0.6 | 0.06 | 0.01 | 3.06 | 1.00 |
| 30351EO | 181.6-184.7 | 07/10/03 | 8.6 | 8.7 | 1.8 | 1.7 | 53.7 | 33.5 | 36 | 36 | 61.2 | 45.4 | - - | - - | 0.3 | 0.2 | 0.02 | 0.01 | 4.19 | 0.85 |
| 30351EO | 236.5-243.0 | 07/10/03 | 8.6 | 8.4 | 1.6 | 1.7 | 50.1 | 46.5 | 42 | 40 | 6.7 | 11.1 | - - | - - | 0.8 | 0.8 | 0.08 | 0.05 | 3.63 | 0.51 |
| 30352EO | 010.0-014.0 | 07/12/03 | 8.0 | 8.1 | 1.1 | 1.4 | 3.6 | 3.6 | 6 | 5 | 5.4 | 7.4 | - - | - - | 0.1 | 0.1 | 0.01 | 0.01 | 0.25 | 0.33 |
| 30352EO | 080.3-086.5 | 07/12/03 | 8.3 | 8.2 | 2.2 | 2.2 | 24.8 | 29.3 | 18 | 14 | 41.4 | 50.2 | - - | - - | 0.1 | 0.2 | 0.07 | 0.01 | 1.36 | 0.87 |
| 30352EO | 133.1-142.2 | 07/12/03 | 7.7 | 7.9 | 4.5 | 5.1 | 43.3 | 49.9 | 31 | 25 | -56.0 | -52.3 | -51.8 | -41.3 | 0.6 | 0.6 | 0.07 | 0.01 | 4.45 | 1.40 |
| 30352EO | 216.0-220.0 | 07/12/03 | 8.7 | 8.8 | 1.2 | 1.3 | 29.4 | 31.8 | 34 | 25 | 8.5 | 13.8 | - - | - - | 0.1 | 0.2 | 0.08 | 0.05 | 2.03 | 0.46 |
| 30353EO | 076.4-085.9 | 07/14/03 | 8.3 | 8.2 | 1.0 | 1.4 | 18.1 | 16.8 | 31 | 29 | 40.5 | 55.6 | - - | - - | 0.4 | 0.5 | 0.04 | 0.01 | 2.17 | 0.70 |
| 30353EO | 148.0-155.6 | 07/14/03 | 8.0 | 7.6 | 1.6 | 1.5 | 6.6 | 3.5 | 11 | 10 | 43.1 | 48.3 | - - | - - | 0.1 | 0.1 | 0.01 | 0.01 | 0.25 | 0.36 |
| 30353EO | 210.0-216.4 | 07/14/03 | 7.6 | 7.3 | 1.1 | 0.9 | 0.8 | 0.8 | 19 | 18 | 8.6 | 30.1 | - - | - - | 0.2 | 0.1 | 0.03 | 0.01 | 0.82 | 0.40 |
| 30353EO | 280.0-290.0 | 07/14/03 | 8.2 | 8.5 | 1.3 | 1.3 | 35.3 | 36.9 | 36 | 34 | 28.2 | 33.6 | - - | - - | 0.3 | 0.5 | 0.10 | 0.01 | 1.46 | 0.42 |
| 30354EO | 047.7-050.0 | 07/15/03 | 6.9 | 7.0 | 4.5 | 4.1 | 15.9 | 14.2 | 35 | 27 | -35.7 | -28.0 | -27.2 | -19.7 | 0.9 | 1.0 | 0.08 | 0.05 | 0.25 | 1.20 |
| 30354EO | 098.8-105.7 | 07/15/03 | 7.1 | 7.0 | 4.5 | 4.4 | 24.3 | 27.4 | 22 | 19 | -14.7 | 7.4 | -9.1 | - - | 0.5 | 0.6 | 0.06 | 0.01 | 0.25 | 0.88 |
| 30354EO | 181.0-189.6 | 07/15/03 | 7.7 | 7.9 | 3.1 | 3.2 | 28.8 | 35.7 | 34 | 29 | -10.5 | 10.8 | 1.3 | - - | 0.4 | 0.4 | 0.04 | 0.01 | 0.25 | 1.10 |
| 30354EO | 265.9-269.3 | 07/15/03 | 8.6 | 8.7 | 1.2 | 1.0 | 38.8 | 25.3 | 44 | 37 | 6.0 | 12.1 | - - | - - | 0.6 | 0.7 | 0.08 | 0.06 | 1.70 | 0.55 |
| 30355EO | 051.4-056.3 | 07/21/03 | 8.3 | 8.5 | 2.2 | 2.1 | 38.0 | 32.7 | 12 | 12 | 51.6 | 90.3 | - - | - - | 0.3 | 0.3 | 0.05 | 0.03 | 0.75 | 0.25 |
| 30355EO | 094.5-98.0 | 07/21/03 | 8.5 | 8.7 | 3.4 | 3.4 | 60.6 | 40.5 | 18 | 19 | 27.7 | 62.2 | - - | - - | 0.3 | 0.3 | 0.09 | 0.05 | 0.78 | 0.15 |
| 30355EO | 172.7-180.0 | 07/21/03 | 9.7 | 9.3 | 0.9 | 1.6 | 32.5 | 27.6 | 32 | 29 | 3.7 | 6.1 | - - | - - | 0.6 | 0.1 | 0.14 | 0.13 | 1.11 | 0.21 |
| 30356EO | 020.8-030.0 | 07/22/03 | 7.0 | 7.2 | 1.9 | 2.5 | 1.9 | 1.8 | 28 | 24 | 13.3 | 26.3 | - - | - - | 0.6 | 0.5 | 0.08 | 0.06 | 1.57 | 0.45 |
| 30356EO | 082.8-091.8 | 07/22/03 | 8.3 | 8.4 | 1.2 | 1.0 | 16.8 | 19.2 | 26 | 26 | 18.4 | 35.3 | - - | - - | 0.3 | 0.2 | 0.03 | 0.03 | 1.52 | 0.46 |
| 30356EO | 139.3-150.0 | 07/22/03 | 7.1 | 7.3 | 1.8 | 2.3 | 1.4 | 1.4 | 30 | 26 | -32.5 | -12.9 | -26.2 | -5.1 | 0.7 | 0.6 | 0.06 | 0.03 | 1.65 | 0.57 |
| 30356EO | 214.1-218.0 | 07/22/03 | 7.5 | 7.7 | 3.1 | 3.1 | 39.4 | 31.8 | 15 | 12 | 7.3 | 26.4 | - - | - - | 0.6 | 0.3 | 0.11 | 0.06 | 0.79 | 0.35 |
| 30357EO | 058.2-063.3 | 07/23/03 | 7.1 | 7.1 | 2.6 | 3.4 | 0.6 | 0.6 | 21 | 19 | 11.8 | 23.7 | - - | - - | 0.8 | 0.5 | 0.08 | 0.06 | 0.98 | 0.27 |
| 30357EO | 149.0-155.1 | 07/23/03 | 7.4 | 7.1 | 3.1 | 5.1 | 10.6 | 6.6 | 16 | 14 | 7.6 | 19.6 | - - | - - | 0.5 | 0.3 | 0.06 | 0.05 | 2.25 | 0.68 |
| 30357EO | 188.7-192.9 | 07/23/03 | 7.6 | 6.7 | 6.2 | 10.9 | 58.1 | 49.9 | 28 | 23 | -60.7 | -58.3 | -64.9 | -40.2 | 1.4 | 1.0 | 0.09 | 0.08 | 1.33 | 0.38 |
| 30358EO | 006.3-016.3 | 07/24/03 | 8.2 | 8.2 | 0.4 | 0.4 | 1.2 | 1.2 | 10 | 6 | 149.0 | 153.0 | - - | - - | 0.2 | 0.1 | 0.01 | 0.02 | 0.25 | 0.14 |
| 30358EO | 087.1-090.8 | 07/24/03 | 7.8 | 7.6 | 2.5 | 3.0 | 36.8 | 37.4 | 25 | 22 | -23.2 | -7.1 | -11.2 | 1.8 | 1.0 | 0.8 | 0.12 | 0.07 | 2.40 | 0.46 |
| 30358EO | 132.2-136.0 | 07/24/03 | 8.2 | 8.2 | 2.1 | 2.7 | 32.3 | 42.5 | 16 | 13 | 18.6 | 27.5 | - - | - - | 0.3 | 0.2 | 0.05 | 0.02 | 0.51 | 0.22 |
| 30358EO | 183.7-188.8 | 07/24/03 | 9.4 | 9.0 | 1.3 | 2.0 | 40.3 | 51.8 | 38 | 24 | 1.4 | 21.3 | - - | - - | 0.7 | 0.4 | 0.20 | 0.13 | 1.53 | 0.3 |
| 30359EO | 045.7-052.0 | 07/25/03 | 7.3 | 7.3 | 2.5 | 2.6 | 0.8 | 0.8 | 31 | 35 | 35.4 | 48.6 | - - | - - | 0.8 | 0.6 | 0.03 | 0.01 | 0.76 | 0.20 |
| 30359EO | 116.7-120.0 | 07/25/03 | 8.6 | 8.7 | 2.0 | 0.7 | 58.8 | 17.5 | 51 | 48 | -9.5 | -26.5 | -0.4 | -9.5 | 1.0 | 0.7 | 0.28 | 0.18 | 0.86 | 0.38 |
| 30360EO | 063.7-065.3 | 07/26/03 | 7.0 | 7.1 | 0.5 | 0.7 | 1.0 | 0.9 | 4 | 0 | -17.9 | -12.0 | 3.2 | 5.4 | 0.6 | 0.6 | 0.01 | 0.01 | 3.44 | 0.89 |
| 30360EO | 134.7-138.3 | 07/26/03 | 8.1 | 8.2 | 1.6 | 1.0 | 47.2 | 27.9 | 28 | 22 | -15.9 | 23.3 | -6.1 | - - | 0.9 | 0.9 | 0.08 | 0.06 | 0.98 | 0.35 |
| 30360EO | 194.0-196.0 | 07/26/03 | 7.8 | 8.0 | 0.9 | 0.9 | 20.4 | 39.0 | 12 | 6 | -13.2 | -17.2 | 4.0 | -0.4 | 2.6 | 2.4 | 0.12 | 0.01 | 2.46 | 0.65 |
| 30361EO | 049.8-054.1 | 07/27/03 | 9.3 | 9.1 | 1.0 | 1.8 | 24.2 | 29.6 | 46 | 28 | 0.4 | 1.7 | - - | - - | 0.6 | 0.7 | 0.23 | 0.15 | 1.72 | 0.22 |
| 30361EO | 092.8-102.5 | 07/27/03 | 9.5 | 9.3 | 1.2 | 1.4 | 36.8 | 40.8 | 41 | 26 | 9.2 | 23.8 | - - | - - | 0.3 | 0.3 | 0.23 | 0.11 | 1.78 | 0.26 |
| 30362EO | 043.0-047.5 | 07/27/03 | 7.7 | 7.1 | 2.9 | 3.0 | 24.1 | 22.2 | 18 | 10 | 17.7 | 2.4 | - - | - - | 0.3 | 0.4 | 0.08 | 0.01 | 0.25 | 0.29 |
| 30362EO | 110.0-120.0 | 07/27/03 | 8.8 | 8.5 | 1.1 | 0.9 | 37.7 | 23.9 | 22 | 10 | 15.5 | 36.4 | - - | - - | 0.1 | 0.1 | 0.04 | 0.01 | 0.87 | 0.28 |
| 30363EO | 010.0-018.5 | 07/28/03 | 7.7 | 7.7 | 4.0 | 4.2 | 0.4 | 0.5 | 14 | 7 | 241.0 | 271.0 | - - | - - | 0.1 | 0.2 | 0.03 | 0.01 | 0.25 | 0.19 |
| 30363EO | 065.6-073.4 | 07/28/03 | 9.0 | 8.8 | 1.5 | 2.6 | 47.8 | 66.5 | 36 | 27 | 12.2 | 33.7 | - - | - - | 0.2 | 0.5 | 0.10 | 0.08 | 0.80 | 0.32 |
| 30363EO | 145.3-150.2 | 07/28/03 | 7.9 | 7.8 | 1.8 | 2.0 | 32.4 | 35.8 | 36 | 26 | -12.2 | -12.1 | -2.0 | -3.8 | 1.7 | 2.0 | 0.05 | 0.15 | 0.80 | 0.38 |

(1) Abbreviations include EC-electrical conductivity; SAR-sodium adsorption ratio; ABP-acid base potential; ABPP-acid base potential pyritic; Set-total selenium; Ses-hot water soluble selenium; and Bhws-hot water soluble boron.

(2) Units are tons calcium carbonate equivalent per 1000 tons of material.

Table 9. Duplicate Core Sample Results for Black Mesa and Kayenta Mines
Analyzed by Green Analytical Lab (GAL) in Durango, Colorado and Energy Lab (EL) in Helena, Montana (1)
2003

| SITE NO. | DEPTH (FEET) | DATE | pH-GAL | pH-EL | EC-GAL (mmhos/cm) | EC-EL (mmhos/cm) | SAR-GAL | SAR-EL | Clay-GAL % | Clay-EL % | ABP-GAL (2) | ABP-EL (2) | ABPP-GAL (2) | ABPP-EL (2) | Set-GAL (ppm) | Set-EL (ppm) | Ses-GAL (ppm) | Ses-EL (ppm) | Bhws-GAL (ppm) | Bhws-EL (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30351EO | 040.0-053.0 | 07/10/03 | 7.4 | 7.7 | 0.4 | 1.9 | 1.3 | 1.3 | 12 | 18 | 4.3 | 10.2 | - - | - - | 0.1 | 0.1 | 0.01 | 0.01 | 0.81 | 0.29 |
| 30363EO | 215.3-218.7 | 07/28/03 | 8.0 | 8.0 | 1.2 | 1.7 | 26.8 | 29.3 | 32 | 22 | 0.6 | 2.3 | - - | - - | 1.4 | 1.6 | 0.10 | 0.07 | 1.96 | 0.44 |
| 30364EO | 057.4-063.4 | 07/29/03 | 8.9 | 8.8 | 1.2 | 1.4 | 31.6 | 19.3 | 49 | 41 | 8.4 | 16.0 | - - | - - | 0.6 | 1.1 | 0.20 | 0.14 | 0.88 | 0.23 |
| 30364EO | 115.0-122.4 | 07/29/03 | 8.7 | 8.7 | 1.3 | 0.9 | 28.2 | 21.9 | 15 | 10 | 6.8 | 13.1 | - - | - - | 0.2 | 0.4 | 0.12 | 0.09 | 0.25 | 0.19 |
| 30365EO | 032.7-041.3 | 07/30/03 | 8.3 | 8.2 | 1.6 | 1.3 | 21.3 | 19.2 | 20 | 11 | 138.0 | 141.0 | - - | - - | 0.1 | 0.4 | 0.05 | 0.01 | 0.67 | 0.18 |
| 30365EO | 123.8-127.0 | 07/30/03 | 8.4 | 8.3 | 1.0 | 1.3 | 28.0 | 33.1 | 51 | 36 | -1.6 | -0.2 | 4.7 | 5.1 | 1.0 | 0.9 | 0.16 | 0.07 | 0.74 | 0.16 |
| 30365EO | 179.6-188.7 | 07/30/03 | 8.3 | 8.3 | 1.4 | 1.5 | 33.7 | 34.5 | 25 | 17 | 26.2 | 27.3 | - - | - - | 0.2 | 0.4 | 0.10 | 0.07 | 0.61 | 0.22 |
| 30366EO | 018.1-030.0 | 08/05/03 | 6.8 | 6.8 | 3.7 | 3.7 | 2.8 | 2.7 | 12 | 6 | 0.2 | 0.8 | - - | - - | 0.2 | 0.1 | 0.01 | 0.02 | 0.57 | 0.28 |
| 30366EO | 111.3-118.0 | 08/05/03 | 8.4 | 8.4 | 1.8 | 2.1 | 31.2 | 30.4 | 48 | 40 | -4.9 | -1.7 | 0.6 | 2.8 | 1.2 | 0.8 | 0.22 | 0.13 | 0.99 | 0.18 |
| 30366EO | 161.1-163.7 | 08/05/03 | 9.0 | 8.9 | 0.9 | 1.2 | 17.6 | 26.4 | 44 | 40 | 2.6 | 6.5 | - - | - - | 1.8 | 1.2 | 0.14 | 0.02 | 0.99 | 0.23 |
| 30367EO | 077.1-082.5 | 08/05/03 | 7.8 | 7.9 | 4.0 | 4.9 | 38.9 | 39.6 | 24 | 23 | -4.2 | 9.1 | -3.7 | - - | 0.8 | 0.6 | 0.09 | 0.05 | 0.25 | 0.17 |
| 30367EO | 131.5-134.5 | 08/05/03 | 8.2 | 8.0 | 2.0 | 1.8 | 14.8 | 27.4 | 28 | 25 | -14.6 | -14.1 | -8.3 | -4.0 | 1.0 | 0.8 | 0.14 | 0.09 | 0.87 | 0.27 |
| 30368EO | 024.0-034.0 | 08/06/03 | 7.1 | 7.3 | 2.1 | 2.6 | 0.5 | 0.5 | 8 | 5 | 7.7 | 10.6 | - - | - - | 0.1 | 0.1 | 0.02 | 0.01 | 0.25 | 0.15 |
| 30368EO | 087.6-093.0 | 08/06/03 | 7.9 | 7.9 | 3.9 | 4.9 | 47.4 | 48.1 | 19 | 19 | -32.3 | -23.2 | -19.5 | -9.5 | 1.3 | 1.3 | 0.13 | 0.10 | 1.25 | 0.25 |
| 30368EO | 147.5-154.0 | 08/06/03 | 8.7 | 8.7 | 1.2 | 1.8 | 31.3 | 33.8 | 44 | 41 | 15.8 | 33.1 | - - | - - | 0.8 | 0.9 | 0.15 | 0.16 | 1.10 | 0.17 |
| 30368EO | 215.9-220.0 | 08/06/03 | 8.6 | 8.5 | 0.9 | 1.4 | 13.1 | 18.6 | 34 | 28 | 2.7 | 9.1 | - - | - - | 0.6 | 0.5 | 0.12 | 0.10 | 2.10 | 0.26 |
| 30369EO | 075.6-084.0 | 08/08/03 | 6.9 | 6.3 | 3.6 | 4.3 | 15.0 | 12.2 | 25 | 22 | -37.5 | -32.0 | -26.4 | -18.8 | 0.9 | 0.9 | 0.08 | 0.06 | 1.40 | 0.33 |
| 30369EO | 124.0-133.6 | 08/08/03 | 7.9 | 7.6 | 2.6 | 3.0 | 31.6 | 26.8 | 15 | 10 | 26.7 | 34.0 | - - | - - | 0.2 | 0.2 | 0.04 | 0.01 | 0.90 | 0.32 |
| 30369EO | 191.6-201.6 | 08/08/03 | 8.8 | 8.7 | 2.0 | 2.0 | 28.8 | 34.1 | 14 | 10 | 6.4 | 10.3 | - - | - - | 0.1 | 0.1 | 0.04 | 0.01 | 0.25 | 0.20 |
| 30370EO | 040.0-044.9 | 08/09/03 | 6.4 | 6.3 | 2.6 | 2.6 | 0.6 | 0.6 | 30 | 24 | -21.6 | -8.0 | -0.5 | 2.0 | 0.6 | 0.8 | 0.04 | 0.02 | 1.38 | 0.47 |
| 30370EO | 090.0-100.0 | 08/09/03 | 8.3 | 8.3 | 1.9 | 2.6 | 48.2 | 58.2 | 48 | 30 | -13.0 | 7.4 | -6.1 | - - | 0.6 | 0.8 | 0.08 | 0.02 | 1.58 | 0.35 |
| 30370EO | 145.5-151.4 | 08/09/03 | 9.0 | 8.7 | 0.8 | 1.6 | 24.7 | 50.5 | 34 | 28 | 8.2 | 29.0 | - - | - - | 0.3 | 0.7 | 0.07 | 0.06 | 1.95 | 0.33 |
| 30370EO | 239.8-246.0 | 08/09/03 | 8.7 | 8.7 | 0.8 | 1.0 | 18.5 | 14.3 | 46 | 35 | 15.1 | 23.6 | - - | - - | 0.3 | 0.5 | 0.10 | 0.05 | 2.32 | 0.40 |
| 30381EO | 047.7-054.0 | 08/10/03 | 8.2 | 8.0 | 1.2 | 1.3 | 2.2 | 2.0 | 11 | 6 | 80.4 | 83.7 | - - | - - | 0.1 | 0.1 | 0.01 | 0.02 | 0.50 | 0.16 |
| 30381EO | 092.5-095.5 | 08/10/03 | 6.6 | 6.6 | 2.0 | 1.7 | 8.8 | 8.3 | 16 | 13 | -32.7 | -38.0 | -28.4 | -14.3 | 2.0 | 1.8 | 0.07 | 0.02 | 6.17 | 1.27 |
| 30381EO | 151.1-154.5 | 08/10/03 | 7.8 | 7.8 | 3.4 | 3.1 | 49.5 | 44.8 | 19 | 16 | -61.7 | -59.7 | -46.2 | -35.5 | 2.4 | 1.6 | 0.11 | 0.06 | 6.23 | 0.36 |

(1) Abbreviations include EC-electrical conductivity; SAR-sodium adsorption ratio; ABP-acid base potential; ABPP-acid base potential pyritic; Set-total selenium; Ses-hot water soluble selenium; and Bhws-hot water soluble boron.

(2) Units are tons calcium carbonate equivalent per 1000 tons of material.

Radioactive Materials

Radioactivity is a part of the energy released by certain naturally occurring unstable elements as their nuclei decay to a more stable state. There are only a few such unstable elements occurring in significant concentrations in coal bearing rock strata. The most common of these elements is potassium 40, with minor occurrences of uranium 238, uranium 235, and thorium 232. Gamma radiation of various levels and intensities are generated during some of these decay processes. The level of natural gamma radiation depends on the chemical composition of the rock. In a coal bearing rock sequence, an increase in natural gamma rays usually reflects an increase of potassium 40, concentrated in clay minerals.

Since 1982 Peabody has incorporated the use of calibrated down-hole digital geophysical logging equipment capable of detecting concentrations of radioactive mineralization in the coal and overburden material. To date, approximately 6,000 drill holes, located throughout Peabody's lease, have been geophysically logged to help delineate coal quantity and quality as well as providing lithologic data on the Wepo formation, the coal bearing formation currently being mined by Peabody.

The geophysical logging suite consists of high-resolution density, natural gamma, resistivity, and caliper logs. The gamma ray log, calibrated in counts per second (cps) is a measurement of the naturally occurring gamma radiation in the rock strata and borehole. Within the Wepo formation on Peabody's lease, the natural gamma log fluctuates from a low of 1 cps in coals and clean sandstones to highs of 80-120 cps in shales and mudstones. These observations are exhibited on typical geophysical logs presented in Attachment 4 to this chapter. The locations of the drill holes whose logs are presented may be found on a map of the leasehold also contained in Attachment 4. To place this range in perspective, a lower grade uranium mineralization would require natural gamma log readings in the 5,000 cps range. Geologic interpretation of all calibrated geophysical logs has provided no evidence of any potential uranium mineralization in the coals or overburden of the Wepo formation within Peabody's lease.

The continued use of advanced geophysical techniques will provide for future evaluation of potentially hazardous radiation occurring in the coal or overburden material. In the highly unlikely event of detecting such mineralization, the appropriate regulatory agencies will be notified.

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