# DEPARTMENT OF ENVIRONMENTAL QUALITY

# LAND QUALITY DIVISION

# GUIDELINE No. 1

# TOPSOIL AND OVERBURDEN

**Last Revised – 11/1984**

**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY LAND QUALITY DIVISION**

**GUIDELINE NO. 1**

**TOPSOIL AND OVERBURDEN**

This document is a guideline only. Its contents are not to be interpreted by applicants or DEQ staff as mandatory. Its preparation is the result of numerous requests from applicants who expressed a need for a checklist to assist them in preparation of a comprehensive initial application containing all required information. Alternate programs should be cleared with DEQ - Cheyenne before use to avoid delays in permit approval. Please note that Guideline 1 is currently under revision but the information regarding overburden remains applicable until the completion of Guideline 1B. Sections regarding topsoil and subsoil have been superseded by Guideline 1A and the information contained in Guideline 1 should be disregarded for those sections. Guideline 1A may be viewed at:

http://deq.wyoming.gov/media/attachments/Land%20Quality/Guidelines/Guideline_1A_Topsoil_Subsoil_(8_2015).pdf

**Introduction**

The guideline is in the following format:

## Section I - Topsoil Resource Assessment

A. **Objectives**

1. Identify the physical and chemical characteristics of the topsoil and delineate those soils into mapping units;
2. Plot, on an appropriate base map, the boundaries of those mapping units;
3. Identify those mapping units that will be salvaged as topsoil for reclamation purposes;
4. Estimate the volumes of topsoil that will be salvaged for reclamation purposes;
5. Provide a basis for the evaluation of the achievability of the proposed post-mining land use.

B. **Soil Survey**

1. General

   a. The soil survey should be conducted in accordance with the standards of the National Cooperative Soil Survey (Reference SCS USDA Handbooks 430 and 436).

   b. The purpose of the soil survey is to assist with the identification and salvage of all suitable topsoil material. Therefore, those site specific characteristics of the topsoil that may influence soil stripping, stockpiling, or respreading should be specifically noted.

2. Maps

   a. The soil survey should cover the entire permit area. Lands to be affected through mining correlated activity should be intensively mapped (Order 1-2). Those areas not to be affected do not need to be mapped as intensively. An order 3 survey is recommended.

   b. Topographic maps or aerial photos can be used as base maps for the soil survey. A scale of 1" = 400' - 700' is desirable.

   c. The operator has the option of providing separate topsoil-stripping maps or placing the stripping depths on the topsoil survey maps. If the single map set is chosen the mine plan should clearly reference this fact. The symbolism on the map should include mapping unit number or letter, soil phase, and stripping depth. For example:

      102A-24 where: 102 is the map unit number
      A is the phase
      24 is the stripping depth

      The legend should provide an example of the symbolism and a list of the mapping units. If separate maps are utilized then a topsoil stripping-depth map for the affected lands, based on a topographic map or aerial photos, should be included at the same scale as the topsoil survey map.

   d. The soil maps should clearly show all soil mapping unit boundaries.

   e. The map should include a complete legend identifying all mapping units and symbols.

f. All maps should be presented as outlined in Guideline No. 6 (6A).

3. Mapping Unit Descriptions

a. Descriptions of mapping units and soil profiles should be consistent with the National Cooperative Soil Survey. Mapping unit descriptions should be specific to the site being studied. Alternative methods can be used.

b. SCS surveys may be used, but refinement and modification may be required to meet the intent of the pre-mining soil survey.

c. Mapping units for the affected lands should be delineated as follows:

(1) If soils are dissimilar (i.e., highly contrasting in physical and/or chemical properties and/or depth of suitable topsoil), consociations of a minimum size of two acres should be delineated.

(2) If soils are similar (i.e., little contrast in physical and/or chemical properties and/or depths of suitable topsoil), consociations of a minimum size of five acres should be delineated. Similar soils may be mapped as associations provided their physical and chemical properties would allow for the same salvage depths.

(3) Soil complex units may be mapped when two or more kinds of soil or miscellaneous areas are in a pattern so intricately mixed that the components cannot be delineated separately at the mapping scale used, i.e., the individual components are less than 2 acres in size.

d. Mapping units for lands which will not be affected should consist of no less than associations and some consociations and complexes. Dissimilar component series of associations should be delineated into consociations when individual series occur as units of 20 or more acres.

e. Mapping unit descriptions should include the site specific percentage of the component series (inclusions, associations and complexes) found in each mapping unit and reflect the site specific conditions of the study area.

f. All mapping units should be correlated with existing SCS soil series, where possible. The local SCS soil survey party leader can be contacted to aid with the correlation process. When soils are significantly different from established soil series, they should be classified and reported to the soil family level.

4. Soil Sampling

a. Sampling sites should be clearly marked on the soils map.

b. Sampling sites should be located where they will represent the mapping unit. They should be placed so that they cover the entire permit area. The number of sampling sites should adequately characterize each mapping unit. It is suggested that at least one sample site be taken for each series found on the affected lands, depending on the size of the mapping unit. The following sample intensities are recommended:

| | |
|---|---|
| 5% of mine area (or 160 acres) | 3 sampled pedons |
| 2-5% of mine area (or 40 to 160 acres) | 2 sampled pedons |
| 2% of mine area (or 40 acres) | 1 sampled pedon |

All inclusions in consociations that make up greater than 1% of the mine area should be sampled at least one time excluding rock outcrop areas. Component soils in complexes and associations should be sampled as above. Additional samples may be necessary to provide information on spatial variability. Some sampling can be deterred by contacting LQD and developing a pre-stripping soil assessment program.

c. A profile description should be taken for each soil being sampled. The major soil horizons, (A, B, and C) should be separately described, sampled, and analyzed. If sub-horizons greater than six inches occur within any major horizon these should also be separately analyzed. Where a major soil horizon is more than 18 inches thick in the lower part (below 2 feet) of the profile or more than 12 inches thick in the upper part, these horizons should be subdivided and sampled. Soil profiles should be sampled to sixty inches or bedrock. When material below sixty inches is suspected of being soil material suitable for reclamation, sampling should continue through the depth of this material if topsoil is limited on the area. The sampling could also continue into paralithic material, if soil materials are in short supply.

5. Soil Analysis

a. Soil samples should be placed into clean polyethylene bags and transported to the laboratory as soon as possible. Chemically unstable constituents, i.e., nitrate-nitrogen, will require special precautions to obtain accurate analysis. Approximately two (2) quarts of material should be provided to the laboratory.

b. Table I-1 (Appendix I) lists the recommended analytical procedure for each parameter. Other procedures may be used if they provide comparable results. However, any changes from the recommended procedures should be cleared with the Land Quality Division prior to analyses.

c. Table I-2 (Appendix I) lists suitability levels for each parameter.

d. Sample preparation should follow the procedure outlined below.

(1) Each of the individual samples collected should be treated together as a whole, through the splitting stage.

(2) Air dry the sample at 30-35 degrees C as soon as possible.

(3) Grind or crush sample such that all fragments that will not slake in water or sodium hexametaphosphate will pass a 2 mm sieve. Record the percent by volume of the greater than 2 mm portion and discard. Record the percent by volume of the less than 2 mm portion.

(4) If the entire sample is not used for the chemical and physical analysis, pass through a sample splitter at least 3 times to collect a representative subsample.

6. Data Presentation

a. All analytical results should be presented in a tabular form by depth and be referenced to the mapping unit, series, sampling site location, and soil horizon.

b. The application should provide the name of the laboratory conducting the analyses, sampling dates, dates of analyses, analytical job number and a list of all methodologies utilized and their references.

7. Topsoil Stripping

   It is recommended that the applicant develop and submit, as a part of the mining plan, a plan of how the operator proposes to salvage all suitable topsoil. The plan could include:

   a. sampling ahead of topsoil salvage, to ensure that all suitable topsoil is salvaged;

   b. training of equipment operators in proper topsoil salvage procedures;

   c. monitoring of topsoil salvage activities in the field by qualified personnel.

   A more detailed program of this kind can be used to reduce the sampling intensity of the baseline study.

8. Volumetric Presentation

   Data derived from the soil survey and analyses should be evaluated to estimate the volumes of topsoil that will be salvaged and be available for reclamation. In this evaluation the following should be presented (Appendix II provides several examples for D-7):

   a. In Appendix D-7 of the application, a table (see Table II-1) should be provided summarizing by mapping unit the extent (acres and percent of total), component series, total topsoil depth and volume, salvage depth and volume, and limiting factors if the salvage depth differs from total depth. The salvage depths for complexes are determined by weighting and summing the salvage depths of the component series.

      Topsoil stripping maps (same scale as topsoil survey map) should also be presented indicating the salvage depth(s), topsoil stripping sequence (by year) and the areas to be affected. (see Section I.B.2.c. of this document).

   b. In the mine plan section, a table (similar to Table II-1), should be provided indicating by mining year for the term of the permit (coal only).

      (1) the acreage of each mapping unit to be affected;

      (2) the average depth of topsoil for each mapping unit; and

      (3) the volumes of topsoil to be salvaged from each mapping unit.

      For the life of the mine, estimates of total topsoil volumes and acreages disturbed should be presented in five year increments.

   c. The destination of the soil material should be specified - i.e., to a stockpile or directly to recontoured overburden. The volumes salvaged, stockpiled, or removed from stockpiles, and the volume and location of replaced topsoil should be specified (Table II-2).

   d. The average depth of topsoil replacement should be specified. If uneven replacement is proposed, clear justification should be presented.

## Section II - Geology, Overburden, Interburden, and Mineral Assessment

### A. Objectives

1. Identify the sequence and position of all lithostratigraphic units above, between and immediately below the mineral deposits to be mined;

2. Identify the location and extent of the mineral to be mined;

3. Identify the physical and chemical properties of the overburden and interburden and the extent of any materials which may have an adverse effect on the environment including animal life, vegetation, air and water quality. Table I-1 (Appendix I) lists the parameters of present concern. Other parameters may be requested based on current information and mine location.
4. An evaluation of the overburden/interburden should be performed to identify any material that would adversely affect reclamation, revegetation, or the quality or quantity of surface or groundwater.
5. The results of the overburden evaluation should be integrated into the mine plan so that the applicant can demonstrate their ability to ensure that all toxic or acid- forming material is stockpiled and backfilled in a manner that will prevent environmental degradation.
6. A reclamation plan should be developed, using the overburden and interburden analyses, demonstrating that toxic or acid-forming overburden material will be placed so as not to preclude surface reclamation and revegetation or the re- establishment of acceptable surface water and groundwater quality and quantity.
7. The volumetric analysis should be integrated into the mine and reclamation plans in a manner demonstrating that the proposed post-mining contours can be established. Special attention should be given to the re-establishment of drainages.

B. **Description of the Overburden, Interburden and Mineral Deposits**

1. The regional geology should be briefly described.
2. The lithostratigraphy of the mineral deposit(s), overburden and interburden should be described for each mining area. The description should include the necessary discussion accompanied by cross-sections and location maps.
   a. The number and spacing of cross-sections will be site dependent; however, it is recommended that two (2) cross-sections per pit be taken with a maximum spacing of one-half mile for parallel sections.
   b. For coal mines, cross-section orientations should be such that one set is parallel to the strike and one set parallel to the dip of the mineral bed.
   c. For uranium deposits, the cross-sections should be oriented to the axis of the ore trend. Spacing should be as recommended above.
   d. Cross-section quality should be suitable for microfilming and ease of assessment. All cross-sections should have common strata at the intersects, complete legends, consistent elevations at common points and consistent scales. Drill hole numbers and depth used for cross-section development should be shown. Cross-sections should extend beyond the pit boundaries and to at least 3 meters below the pit floor or to potentially affected aquifers below the pit floor.
   e. Cross-sections should be constructed directly through points (minimum of three) where chemical, physical and electro-physical data are available.

      **NOTE:** It is recommended that Land Quality personnel be consulted prior to the placement of the drill holes.
   f. Presentation of the cross-sections should be at a scale of 1" = 50' vertical, and 1" = 200-

400' horizontal and illustrate the following:

(1) The position and extent of each lithostratigraphic unit, mineral deposit(s), and unconsolidated sediment units;

(2) Alluvial deposits, fractures and fault zones;

(3) Aquifers or saturated zones;

(4) The floor and lateral boundaries of each proposed mining block or pit;

(5) Location of test holes used to construct the cross-section;

(6) Potentially toxic or acid forming zones.

g. Cross-section locations should be plotted on a map (1" = 400' - 1,000') which identifies the location and number of each drill hole used for analysis and construction of the cross-section. Off-set drill holes used for development should not be more than 200 feet from the cross-section line. All cross-sections must be certified by a Professional Geologist or Engineer (coal only). Detailed geologist log and geophysical log should be submitted as part of Appendix D-5 for all drill holes.

h. The nature of the mineral deposits to be mined should be defined according to the criteria in the Wyoming Environmental Quality Act 35-11-406(a)(vii) and (x) and the Wyoming Rules and Regulations Chapter II Section 2(a)(vi)(K)(III) coal and Chapter II, Section 2(a)(i)(F)(IV) noncoal and Chapter II Section 3(a)(vi)(I)(IV) coal and Chapter II Section 3(b)(viii) coal.

3. Overburden Sampling

a. Sample holes should be located so as to adequately represent the quality of the overburden and interburden. The following sampling procedures are recommended.

(1) Overburden sampling can be conducted in a two stage program. For the purposes of the initial permit application submittal, (1st stage), sampling intensity should be one sample hole per 80 acres (eight per section). Holes should be relatively evenly spaced and at least two holes per section should be cored. Stage two is a progressive sampling scheme and would consist of utilizing developmental and exploratory drilling to further describe and delineate the overburden characteristics for special handling considerations. The intensity of the combined sampling stage should be one hole per 40 acres (16 per section). Additional or more intense sampling may be requested based on site characteristics. Sample holes should extend to below the mineral to be mined.

The operator has the alternative of submitting data on 4 holes per section (1 cored) for baseline and increasing intensities of sampling data during stage 1.

(2) If the proposed pit size is to be less than 80 acres, then at least two holes should be taken. At least one of these holes should be cored.

(3) For areas with dipping mineral seams, the holes should generally be located on the low side of the dip to insure that all overburden is sampled. Holes should be parallel to the strike at the appropriate spacing.

(4) Legible detailed geologist logs should be provided for each sample hole. Descriptions should include depth intervals, rock type, rock color and associated minerals. For sandstones and siltstones grain size, shape, sorting and cementing

agents should be described. For claystones and shales, texture and bedding should be included. A geologist should be present to collect samples to prevent uphole contamination and maintain the descriptive logs.

(5) Geophysical logs should be submitted in a legible form for all core holes. For the geologic cross-sections, one log per 1,000 feet should also be provided. Additional logs may be required on a site specific basis. Revised geologic logs developed from driller logs and geophysical interpretations should be submitted. All interpretations from geophysical logs without a descriptive log as a backup should be noted as a log interpretation only. If only one curve is used for interpretation it should be noted as such and used only as extrapolation between points with adequate logs. Logs with an excess of 50% off scale caliper are not acceptable for interpretation. All new logs should provide the information outlined in items (a) through (f):

(a) 1:10 scale.

(b) At least three curves and a caliper clearly labelled.

(c) Complete headers.

(d) "0" points and quantitation scales for each curve.

(e) Density curve must have a caliper for interpretation.

(f) Sufficient deflection to visually pick out all lithotypes represented.

b. All lithostratigraphic units and unconsolidated units of the overburden and interburden should be sampled and evaluated by laboratory analyses. Recommended procedures for sampling are:

(1) Drilling methods that prevent contamination of samples should be used (Power and Sandoval, 1976). Metal additives in certain drill stem joint lubricants have presented problems during evaluation. Metals such as, but not limited to, zinc, molybdenum, copper and lead have appeared at elevated levels in overburden analyses and have been traced directly to the lubricants. Other potential problems may arise from drilling fluids containing salts or alkali. The applicant should evaluate and document materials used in the drilling process in case problems occur;

(2) for drill holes where chip samples are collected, a composite sample should be taken for every five (5) feet of thickness, i.e., 0-5 ft., 5-10 ft., 10-15 ft.;

(3) for cored drill holes each ten (10) foot section of the core should be ground, thoroughly mixed (with one half used for analysis and the other half stored for possible future use). The data should then be correlated back to the geophysical and drillers' logs;

(4) each lithostratographic unit sampled should be designated by thickness, depth, and hole number;

(5) coal that is to be spoiled (rider seams, thin stringers, etc.) should be sampled as overburden;

(6) polyethylene plastic bags should be used for sample collection and shipping. Moist or

wet samples should be immediately frozen or spread to dry on a waterproof material, stored in closed water resistant containers until analyzed. Chemically unstable constituents, i.e., nitrate-nitrogen, will require special precautions to obtain accurate analysis.

4. Laboratory Analysis

   a. Table I-1 (Appendix I) lists the current parameters of greatest concern for establishing overburden and interburden quality and the recommended methods of analysis. Any change in the recommended procedures should be cleared with the Land Quality Division before analysis.

   b. Analysis of parameters in addition to those listed in Table I-1 may be required based upon the geologic nature of a mining area or if information is obtained which indicates a problem may exist. It is recommended that Land Quality personnel be consulted prior to doing any analytical work.

C. **Overburden Sample Preparation**

To reduce variability between sampling and laboratories a standardized procedure should be followed prior to all chemical and physical characterizations. For chip samples enough material should be supplied to the laboratory to run all analyses (two quarts suggested).

1. After air drying, the entire core or chip sample should be crushed and ground until approximately 95% of the sample passes through a 10 mesh sieve. Utilization of the fines without crushing the entire sample is not acceptable.
2. After grinding, the entire sample should be passed through a sample splitter at least three times. If the split samples are not visually homogeneous, this procedure should be continued until representative splits are obtained.
3. Additional grinding may be required on the representative sample split retained for analysis. Check the recommended methodologies prior to analysis.

D. **Acid-Base Accounting**

The acid-base potential (ABP) measurement is a two part determination: the acid potential (AP) and the neutralization potential (NP). After the acid potential is converted to CaCO3 equivalents the two values are summed. The acid potential is ordinarily assigned the negative value. This allows the reporting of a deficiency of CaCO3 as a negative acid-base potential.

All labs should report three values for the acid-base potential; the acid potential, the neutralization potential and the acid-base potential calculation. The acid potential is either reported as meg H/100g or % Sulfur. Hot water soluble sulfates should be removed prior to sulfur analysis. Hydrochloric acid is not an acceptable rinse for sulfate removal. One of the following calculations are necessary to convert the acid potential to CaCO3 equivalents.

1. $$\text{meg H/100g} \times 0.01 = \frac{\text{tons H+}}{\text{1000 tons material}}$$

$$\frac{\text{tons H+} \times 50}{\text{1000 tons material}} = \frac{\text{tons CaCO3 required}}{\text{1000 tons material}}$$

2. %S- SO4 x (31.24) = $\frac{\text{tons CaCO3 required}}{\text{1000 tons materials}}$

The neutralization potential will be reported as either % CaCO3 or tons CaCO3/1000 tons material. To convert % CaCO3 to tons/1000 tons use the following calculation:

3. % CaCO3 x 10 = tons CaCO3 present/1000 tons material.

Tons per 1000 tons is used as a reference point since this value represents an acre furrow slice. Calculation #4 converts acid potential (AP) and neutralization potential (NP) to the acid-base potential.

4. (-AP) + NP = ABP or NP - AP = ABP.

If the resultant value is less than -5 tons CaCO3/1000 tons an acid-forming potential exists for the sample.

**Section III - Pre-mining and Post-mining Topographic (Slope) Assessment**

Slope assessments need to be conducted for both pre-mining and proposed post-mining surfaces. A square grid pattern, representing 400 feet between sampling points, overlain on topographic maps is recommended for slope determinations. The same sampling points are used for both pre- mining and post-mining surfaces. Statistical analyses can then be completed using the slope value at each sampling point. It is recommended that the slope data include: minimum slopes, maximum slopes, means, and the percentage for each slope class for both pre-mining and post-mining surfaces. In addition, topographic maps must be included for both pre-mining and post-mining surfaces. The data should be presented in Appendix D-5 and be cross-referenced in Appendix D-6 and the reclamation plan.

**Section IV - Post-mining Fertility Assessment and Regraded Overburden Monitoring and Suitability Assessment**

A. The success of the methods employed to mitigate the impacts of toxic, acid-forming or vegetative retarding materials will be assessed through a regraded overburden monitoring program. Each applicant should submit as part of the Reclamation Plan, a detailed monitoring program to include grid spacing, parameters to be tested, sampling patterns to delineate any unsuitable areas and mitigation measures to be employed. Sample composites should not exceed a 2 foot maximum depth and sampling should be completed to a minimum of 4 feet. Visual assessment as well as organic carbon analysis should also be conducted to determine the occurrence of carbonaceous or coaly material. Before topsoiling the operator shall request Land Quality District approval to topsoil any area which has been backfilled and regraded to final contour.

B. **Organic Carbon**

As the regraded spoil monitoring program is conducted, the entire site should be visually assessed for the presence of coal and/or carbonaceous wastes. If these wastes are seen, the operator should take action to cover these wastes with four feet of suitable materials or sample the area to determine the suitability. Carbonaceous material is defined by an organic carbon content of 10% or more as measured by the method referenced in Table I-1. The numerically defined limit protects all parties involved from incorrect designations.

C. Following spoil contouring and topsoil replacement, soil sampling and testing should be conducted to determine the fertility of the replaced material. The nutrient status of the replaced soil (parameters listed in column 1 of Table I-3, Appendix I) and the nutrient requirements of the vegetation species being planted should be considered when determining fertilizer application rates. The reclamation plan should include a tentative post-mining sampling plan indicating methods and intensity of sampling. (Sample should be a composite to two feet of depth).

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## APPENDIX I - SECTION 1

Parameters, Analytical Procedures and Suitability Criteria for Topsoil and Overburden Analyses and Evaluation.

Table I-1: Recommended procedures for analyzing soils and overburden/interburden quality for coal, uranium and bentonite mines.

| Parameter | | | | Recommended Procedure | |
|---|---|---|---|---|---|
| Topsoil | | Overburden/ Interburden | Reported As | Extractant | Analytical |
| 1. | pH | pH | Hydrogen ion activity | USDA Handbook 60, method (2), pg. 84 (saturated paste). | USDA Handbook 60, method (21a), pg. 102 |
| 2. | Conductivity | Conductivity | mmhos/cm @ 25 c | USDA Handbook 60, method (3a), pg. 84. | USDA Handbook 60, method (3a), pg. 84 and method (4b), pg. 89-90 |
| 3. | Saturation | Saturation | Percent | | USDA Handbook 60, method (27a) or (27b), pg. 107. |
| 4. | Particle size Analysis | Particle size Analysis | % clay, silt, sand, and very fine sand (vfs=0.05 - 0.1 mm) | | ASA Mono. No. 9, Pt. 1 method 43-5, pgs. 562-566. Sieve analysis for very fine sand. |
| 5. | Texture | Texture | USDA textural class | | USDA Handbook 18, pgs. 205-223. |
| 6. | Soluble Ca, Mg, and Na | Soluble Ca, Mg, and Na | meg/1 | USDA Handbook 60, method (3a), pg. 84. | USDA Handbook 60, method (3a) pg. 84. Analysis by AA or ICP. |
| 7. | Sodium-absorption ratio | Sodium-absorption ratio | SAR Calculated from soluble Ca, Mg, and Na concentrations | | Calculated: USDA Handbook 60, pg. 26. |
| 8. | Carbonates | | Percent | | USDA Handbook 60, method (23c) pg. 105. |
| 9. | Selenium 1/ | Selenium | ppm to a lower detection limit of 0.01 | ASA Mono. No. 9, Pt. 2 (1st Ed.), method 80-3.2 pg. 1122 or ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55. | For hydride generation, pretreat extract according to ASA Mono. No. 9, Pt. 2, method 3-5.5.4, pg. 61. Hydride generation for AA (U.S. EPA, 1979) or ICP by ASA Mono. No. 9, Pt. 2 method 3-5.5.3. pg. 60. |

| | | | | | |
|---|---|---|---|---|---|
| 10. | Boron 2/ | Boron | ppm | ASA Mono. No. 9, Pt. 2 method 25-9.1, pg. 443. | ICP or ASA Mono. No. 9, Pt. 2, Method 25-5. pg. 435. |
| 11. | | Nitrate-Nitrogen | ppm | ASA Mono. No. 9, Pt. 2, method 33-3.2, pg. 649. | ASA Mono. No. 9, Pt. 2, method 33-8.2, pg. 679. |
| 12. | Organic Matter | | Percent | | ASA Mono. No. 9, Pt. 2 method 29-3.5.2, pg. 570. |
| 13. | | Organic Carbon 3/ | Percent | | Dean (1974) |
| 14. | | Molybdenum | ppm to a lower detection limit of 0.1 | (NH4) 2CO3 (Vlek, 1975) or ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55 or ASA Mono. No. 9, Pt. 2 (1st Ed) method 74-2.3., pp. 1056-1057. | Furnace AA, ICP or ASA. Mono. No. 9, Pt. 2, (1st Ed) method 74-2, pp. 1054-1057 |
| 15. | | Acid potential (AP) | meg H/100g or % sulfur | | Sulfur furnace (Smith et al, 1974) or ASA Mono. No. 9, Pt. 2, methods 28-2.2.3, pg. 512-514. |
| 16. | | Neutralization potential (NP) | %CaCO3 or tons CaCO3/1000 tons material | | USDA Handbook 60, method (23c), pg. 105. |
| 17. | | Acid-base potential (ABP) | tons CaCO3/1000 tons material | | Calculated: ABP = NP - AP |
| 18. | | Arsenic 4/ | ppm | ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55. or method 24-5.4, pg. 421. | Pretreat extract according to ASA Mono. No. 9., Pt. 2, method 3-5.5.5, pg. 61. Hydride generation for AA (U.S. EPA, 1979) or ICP by ASA Mono. No. 9, Pt. 2, method 3-5.5.3, pg. 60. Furnace AA also acceptable (U.S. EPA, 1979). |
| 19. | Coarse Fragment | | Percent | | USDA Handbook 436, App. I, Pg. 472. SCS (1972) pgs. 9 & 12-13. |

1/ Analysis for selenium recommended on soils where primary selenium indicator plants are present.

2/ Analysis recommended for mining operations in Sweetwater County, Wyoming and all bentonite operations.

3/ Analysis recommended for regraded coal mine spoils.

4/ Analysis recommended for uranium operations.

**Table I-2: Criteria to establish suitability of topsoil (or topsoil substitutes).**

| Parameter | Suitable | Marginal 1/ | Unsuitable |
|---|---|---|---|
| pH | 5.5-8.5 | 5.0-5.5<br>8.5-9.0 | <5.0<br>>9.0 |
| EC (Conductivity) mmhos/cm | 0-8 | 8-12 | >12 |
| Saturation Percentage | 25-80 | <25<br>>80 | |
| Texture | | c,sic,s | |
| SAR 2/ | 0-10 | 10-12 3/<br>10-15 | >12 3/<br>>15 |
| Selenium | <0.1 ppm | >0.1 ppm | |
| Boron | <5.0 ppm | | >5.0 ppm |
| Coarse Frag (% vol) | <25% | 25-35 | >35% |

1/ Evaluated on an individual basis for suitability.

2/ As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.

3/ For fine textured soils (clay >40%)

**Table I-3: Parameters recommended for determining fertility status of soil on reclaimed land surface. 1/**

| | Parameter | Reported As | Recommended Procedure |
|---|---|---|---|
| 1. | Nitrate-Nitrogen | ppm | ASA Mono. No. 9, Pt. 2, method 33-3.2, pg. 649. Analysis by ASA Mono. No. 9, Pt. 2, method 33-8.2, pg. 679. |
| 2. | Phosphorus | ppm | ASA Mono. No. 9, Pt. 2, method 29-3.5.2, pg. 570. |
| 3. | Organic Matter | Percent | ASA Mono. No. 9, Pt. 2, method 29-3.5.2, pg. 570. |
| 4. | Potassium | ppm | ASA Mono. No. 9, Pt. 2, method 24-5.5, pg. 422. Analysis by AA or ICP. |
| 5. | pH | | USDA Handbook 60, method (21a), pg. 102. |
| 6. | Conductivity | mmhos/cm@25 degrees Celsius | USDA Handbook 60, method (3a), pg. 84 and method (4b), pg. 89. |
| 7. | Soluble Ca, Mg, Na | meg/l | USDA Handbook 60, method (3a), pg. 84. Analysis by AA or ICP. |
| 8. | Sodium absorption ration | | Calculated from: USDA Handbook 60, pg. 26. |
| 9. | Texture | USDA Textural class | USDA Handbook 18, pg. 205, 223. |
| 10. | Particle Size Analysis | % clay, silt, sand, and very fine sand (vfs=0.05 – 0.1mm) | ASA Mono. No. 9, Pt. I, method 43-5, pgs. 562-566. Sieve analysis for very fine sand. |

1/ Dates of sampling and analysis should be provided.

## Table I-4: Criteria to establish overburden suitability

| | | Surface (potential root zone) | | Aquifer Restoration |
|---|---|---|---|---|
| Parameter | Suitable | Marginal 1/ | Unsuitable | Unsuitable |
| pH | 5.5-8.5 | 5.0-5.5 | <5.0 | <5.0 |
| EC (Conductivity) mmhos/cm | 0-8 | 8-12 | >12 | Depends on premining water quality and overburden quality |
| Saturation Percentage | 25-80 | <25<br>>80 | | |
| Texture | | c,sic,s | | |
| SAR 2/ | 0-10 | 10-12 3/<br>10-15 | >12 3/<br>>15 | Depends on premining water quality and overburden quality |
| Selenium | <0.1 ppm | >0.1 ppm | | Depends on premining water quality and overburden quality |
| Boron | <5.0 | | >5.0 ppm | Depends on premining water quality and overburden quality |
| Nitrate/Nitrogen | | | | >50 ppm |
| Molybdenum | <1.0 ppm | >1.0 ppm | | |
| Acid/base pot. 4/ | >-5 CaCO3 equivalent/1000 tons | | <-5 tons CaCO3 equivalent/1000 tons | <-5 tons CaCO3 equivalent/1000 tons |
| Arsenic | <2.0 ppm | >2.0 ppm | | Depends on premining water quality and overburden quality |
| Organic Carbon | <10% | | >10% | |

1/ Evaluated on an individual basis for suitability.

2/ As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.

3/ For fine textured soils (Clay 40%).

4/ Record as Acid pot., Neutralization pot. and acid-base potential in ± tons CaCO3 equivalent/1000 tons.

## Appendix II

### Topsoil Volume Calculation Example

This appendix provides examples of how topsoil data should be calculated and presented. Five tables are included:

1. Table II-1 lists the soil mapping units found on a hypothetical 640-acre mine area, all of which will be affected. Consociations (i.e., Bidman Loam), complexes, and associations are listed. Average depths of suitable material and volumes are presented. It is recommended that this table be included in Appendix D-7 of the permit application and referenced in the Mine Plan.

2. Table II-2 lists topsoil balance information. Of particular importance are the locations of topsoil removal and replacement and volumes of topsoil removed, stockpiled and replaced. This table should correspond to the topsoil stripping and replacement schedule maps, the topsoil replacement table (Table II-3), and the topsoil stockpile Tables (Tables II-4 and II-5). It is recommended that this table be included in the Mine Plan portion of the permit application.

3. Table II-3 indicates estimated depths of replaced topsoil. It is particularly important that the source of topsoil material, year and location of topsoil replacement be specified. It is recommended that this table be included in the Reclamation Plan of the permit application.

4. Table II-4 lists topsoil life expectancy, volume, area, height and side slopes. It is recommended that this table be included in the Mine Plan portion of the permit application.

5. Table II-5 gives an example of how a stockpile balance can be presented for the entire life of the mine. The table is designed to show how much topsoil is stockpiled in any given stockpile for any given year. It is recommended that this table be included in the Mine Plan portion of the permit application.

## Table II-1
## <u>Topsoil Volume Summary</u>

| Mapping Unit Symbol & Name | Composition of Mining Area % | Acres | Composition of Mapping Unit in % (Should include inclusions) | Depth of Topsoil (inches) | Total Volume of Topsoil (A-ft) | Average Salvage Volume of Topsoil (A-ft | Salvage Depth of Topsoil (inches) | Limitations 1/ |
|---|---|---|---|---|---|---|---|---|
| 1A Haverson loam | 25.6 | 4.0 | 100 | 60+ | 128.0 | 59.76 | 28.0 | SAR 15 at 28 in |
| 2B Bidman loam | 76.8 | 12.0 | 90 | 60 | 345.0 | 345.0 | 60.0 | |
| (Briggsdale sandy loam) | | | 10 | 29 | 18.6 | 18.6 | 29.0 | |
| 44C Tassel-Shingle | 44.8 | 7.0 | | | | | | |
| Rock outcrop | | | 50 | 18 | 33.6 | 33.6 | 18.0 | |
| Complex | | | | | | | | |
| Tassel | | | | | | | | |
| Shingle | | | 25 | 8 | 7.5 | 7.5 | 8.0 | |
| Rock Outcrop | | | 25 | 0 | 0.0 | 0.0 | 0.0 | |
| 5A Stoneham loam | 96.0 | 15.0 | 90 | 60 | 432.0 | 432.0 | 60.0 | |
| (Cushman) | | | 10 | 24 | 19.2 | 19.2 | 24.0 | |
| 7B Briggsdale sandy loam | 140.8 | 22.0 | 95 | 29 | 323.3 | 323.3 | 29.0 | |
| (Shingle) | | | 5 | 12 | 7.0 | 7.0 | 12.0 | |
| 9A Ft. Collins-Ulm | 70.4 | 11.0 | | | | | | |
| Association | | | 50 | 60 | 176.0 | 176.0 | 60.0 | |
| Ft. Collins | | | | | | | | |
| Ulm | | | 45 | 60 | 158.4 | 158.4 | 60.0 | |
| (Shingle) | | | 5 | 12 | 3.5 | 3.5 | 12.0 | |
| 6B Thedalund | 108.8 | 17.0 | 100 | 24 | 217.6 | 217.6 | 24.0 | |
| 9B Cushman | 76.8 | 12.0 | 100 | 24 | 153.6 | 153.6 | 24.0 | |
| **TOTAL** | 640.0 | 100.0 | | | 2023.3 | 1954.9 | | |

( ) indicates inclusion

Average depth of replacement
$\frac{1954.9 \text{ A-ft}}{640 \text{ A}} = 3.0$ ft.

<u>1</u>/ Where topsoil salvage depth is different from the depth of topsoil, the limiting factor should be defined.

# Table II-2
# Topsoil Balance

| Year | Stripping Area 1/ | Acres | Volume Removed | Destination Stockpile No. 2/ or Replacement Area 3/ | Volume Stockpiled (bcy) | Volume Replaced (bcy) | Stockpile No. | Year Removed | Volume Removed (bcy) | Stockpile Designation | Running Stockpile Volume (bcy) | Total Topsoil Volume Replaced Per Year (bcy) | Running Total Volume Replaced (bcy) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 1N | 300 | 1,064,800 | S-1 | 1,064,800 | 0 | 0 | 0 | 0 | S-1 | 1,064,800 | 0 | 0 |
| 1981 | 2N | 150 | 423,500 | S-2 | 169,400 | | 0 | 0 | 0 | S-2 | 169,400 | | |
| | | | | 1N-A | | 254,100 | | | | | | 254,100 | 254,100 |
| 1982 | 3N | 180 | 580,800 | 1N-B | | 580,800 | | | | | | | |
| | | | | 2N | | | S-1 | 1982 | 556,600 | S-1 | 508,200 | 1,137,400 | 1,391,500 |
| 1983 | - | - | - | 3N | - | 677,600 | S-1 | 1983 | 508,200 | S-1 | 0 | 677,600 | 2,069,100 |
| | | | 2,069,100 | | | | | | | | | | |

1/ Stripping areas should be clearly delineated on the topsoil sequence map. The stripping area time period should not exceed one year.

2/ The topsoil stockpiles should be shown and numbered on the mine sequence maps.

3/ The topsoil replacement areas (by year) should be delineated on the topsoil replacement sequence map.

**Table II-3. Topsoil Replacement**

| Year | Replacement Area 1/ | Source of Topsoil 2/ | Volume of Topsoil Replaced (bcy) | Area Retopsoiled (acre) | Average Depth of Topsoil Replacement (inches) |
|---|---|---|---|---|---|
| 1982 | 1N | Stockpile 1 | 481.1 | 170 | 34 |
| 1983 | 1N | Stockpile 1 | 400.0 | 280 | 37 |
| | | 1S | 463.3 | | |
| 1984 | 2N | 3N | 900.0 | 300 | 36 |
| 1985 | 3N | 4N | 568.7 | 195 | 35 |
| 1986 | 4N | Stockpile 4 | 1237.5 | 450 | 33 |

1/ The areas of topsoil replacement (yearly) should be delineated on a topsoil replacement sequence map.

2/ The topsoil volume balance tables located in the mine plan should be cross referenced.

**Table II-4  Topsoil Stockpile Information**

| Years of Existence | Stockpile Designation | Maximum Capacity (bcy) | Maximum Basal Area (AC) | Average Height of Stockpile (ft) | Maximum Side Slopes |
|---|---|---|---|---|---|
| 1980-1981 | 1A | 26,888.0 | 1.0 | 25 | 3:1 |
| 1985-2000 | 1C | 134,444.0 | 5.0 | 25 | 3:1 |
| 2000-2025 | 2A | 322,666.0 | 12.0 | 25 | 3:1 |
| 1990-2020 | 3A | 280,000.0 | 10.4 | 25 | 3:1 |

**Table II-5 Stockpile Volume (bcy) Balance for the Life of the Mine**

| Stockpile Designation | Year 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| S-1 1/ | 10,000 | 15,000 | 15,000 | 15,000 | 10,000 | 5,000 | 0 |
| S-2 | - | - | 20,000 | 20,000 | 10,000 | 0 | 0 |
| S-3 | - | - | - | 15,000 | 15,000 | 0 | 0 |
| S-4 | - | - | - | - | 9,000 | 9,000 | 0 |
| OB-1 2/ | 150,000 | 380,000 | 380,000 | 380,000 | 0 | 0 | 0 |
| OB-2 | - | - | 500,000 | 500,000 | 250,000 | 0 | 0 |
| OB-3 | _ | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 0 |
| OB-4 | 275,000 | 275,00 | 275,000 | 275,000 | 275,000 | 275,000 | 0 |

1/ Topsoil Stockpile

2/ Overburden Stockpile

# Appendix III

Overburden Volume Calculation Example

This appendix provides examples of how overburden data should be calculated and presented. Two tables are included:

1. Table III-1 gives an example of coal and overburden removal volumes and estimated amount of overburden available for backfill. It is recommended that this table be included in the Mine Plan portion of the permit application.

2. Table III-2 lists overburden stockpile information. It is recommended that this table be included in the Mine Plan portion of the permit application. Permanent overburden stockpiles should be identified separately from temporary overburden stockpiles.

3. Table II-5 (Appendix II) gives an example of how the stockpile balance can be presented for the entire life of the mine. The table is designed to show how much overburden will be stockpiled in any given stockpile for any given year.

The figures and data presented in this appendix do not necessarily reflect true field conditions but are presented to exemplify the preferred format of data presentation.

## Table III-1 Overburden Material Balance

| | | | Coal Production | | | | | | | Running Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time 1/ | Cut 2/ | Area (Acres) | (Tons) | (CY) 3/ | Overburden Removal Method 4/ | Overburden Volume (BCY) | Destination 5/ | Backfill Volume 6/ (LCY) | Backfill Origin | Overburden (BCY) | Backfill (LCY) | Stockpile (LCY) |
| 1981 | 1N | 75 | 0 | - | Truck Shovel | 12,000 | SP-1 | 0 | - | 21,000 | - | 23,210 |
| | 1S | 140 | 300,000 | 277,800 | Dragline | 1,300,000 | 1S | 1,443,000 | 1S | 1,321,000 | 1,443,000 | 23,310 |
| 1982 | 1N | 75 | 400,000 | 370,370 | Dragline | 519,000 | 1N | 576,000 | 1N | 1,840,000 | 2,019,100 | 23,310 |
| | 1S | 140 | 600,000 | 555,556 | Scraper | - | - | 21,000 | SP-1 | 1,840,000 | 2,040,000 | 2,310 |
| | 2N | 92 | - | - | Truck Shovel | 350,000 | SP-2 | - | - | 2,190,000 | 2,040,100 | 352,310 |
| | 2N | 92 | - | - | Truck Shovel | 140,000 | 1N | 155,400 | 2N | 2,300,000 | 2,195,500 | 352,310 |
| 1983 | 3N | 88 | 400,000 | 370,370 | Truck Shovel | 800,000 | 1N | 888,000 | 3N | 3,130,000 | 3,083,500 | 352,310 |

1/ Time increments should be a maximum of one year.

2/ Cut, bench number, pit, etc. These areas should be clearly designated on the mine sequence map, or the backfill sequence map, whichever applies.

3/ Use a reasonable (or calculated) coal density (25 ft. 3/ton was used here).

4/ If a single pit is utilizing more than one method, use separate lines, as shown.

5/ The destination should correspond to a stockpile or a cut to be backfilled. If there are more than two destinations, use separate lines.

6/ A swell factor of 11% is used here and in the stockpile calculation.

## Table III-2  Overburden Stockpile Information

| Years of Existence | Stockpile Designation 1/ | Basal ft | Area acres | Average Height (ft) | Maximum Capacity Volume (LCY) | Maximum Side Slopes (h:v) |
|---|---|---|---|---|---|---|
| 1980-1985 | 160 B-2 | 496,500 | 11.40 | 33 | 463,200 | 3:1 |
| 1981-1989 | 160 B-3 | 3,378,000 | 77.55 | 47 | 5,201,600 | 3:1 |
| 1982-1990 | 160 B-4 | 319,000 | 7.34 | 14 | 138,600 | 3:1 |
| 1990-2025 | 160 B-5 | 737,700 | 16.94 | 26 | 545,000 | 5:1 |
| 1995-2025 | 170 B-1 | 5,946,900 | 136.52 | 57 | 9,910,000 | 3:1 |

## Appendix IV

Definitions

The first two terms have been defined in the Wyoming Rules and Regulations and should not be redefined.

Topsoil means soil which may consist of the A, B, and C soil horizons or any combination thereof and which has been determined through soil surveys, laboratory analyses and field trials to be suitable as a plant growth medium for the postmining land use. Soil is unconsolidated mineral material in the immediate surface of the earth that serves as a natural medium for the growth of plants and differs from material from which it was derived in many physical, chemical, biological and morphological properties and characteristics.

Subsoil means any subsurface earthen materials, excluding any material within the topsoil layer, which is capable of supporting plant life.

Soil Survey Orders

| Kinds of Soil Survey | Kinds of Map Units | Kinds of Components | Field Procedures |
|---|---|---|---|
| 1st Order | Mainly consociations and some complexes | Phases of soil series | The soils in each delineation are identified by transecting and traversing. Soil boundaries are observed throughout their length. Air photos used to aid boundary delineation. |
| 2nd Order | Consociations, associations and complexes | Phases of soil series | The soils in each delineation are identified by transecting and traversing. Soil boundaries are plotted by observation and interpretation of remotely sensed data. Boundaries are verified at closely spaced intervals. |
| 3rd Order | Associations and some consociations and complexes | Phases of soil series and soil families | The soils in each delineation are identified by transecting, traversing and some observations. Boundaries are plotted by observation and interpretation by remotely sensed data and verified with some observations. |

## Appendix V

Report Outline with Table and Data Formats

A. Outline for Soil Resource Assessment, Appendix D-7

Introduction
Methods
- Soil Survey Field
- Sampling
- Laboratory
- Analysis

Results and Discussion
- Soil Survey
- Soil Mapping Unit Interpretation
- Chemical and Physical Data
- Depth(s) for Each Soil Mapping Unit (Table III-1 included here) Mapping Unit Descriptions
- Profile Descriptions
- Prime Farmland Assessment

B. Outline for Geology, Overburden, Interburden, and Mineral Assessment, Appendix D-5

Introduction
Regional Geology
Local (Permit Area) Geology
Methods
- Drilling Methods
- Sampling
- Methods
- Laboratory
- Analysis

Overburden Assessment
Conclusions
Surficial Geology Map
Lithologic Logs (Geologist and Geophysical) Cross-Sections
Chemical and Physical Data
Mineral Assessment (BTU's, ash, water content, sulphur, grade, etc.) Coal and Overburden Isopach Maps

C. Outline for the Mine and Reclamation Plans

The mine and reclamation plans should follow an outline similar to the format of Guideline 6 (6A). The Guideline 6 (6A) outline may not be inclusive and may need modification for specific areas. A table of contents should be included which defines where each section or subsection can be found.

## APPENDIX VI

## SELENIUM IN SPOILS OF UPLAND AREAS AND EPHEMERAL DRAINAGES FOR SURFACE COAL MINES

*(NOTE: This appendix is intended to be added to Guideline No. 1. It consists of pages taken directly from the guideline and modified to reflect the Subcommittee on Soils, Vegetation, Overburden, and Wildlife (SVOW) position paper on selenium, and proposed mitigation plans. The changes are in italicized underlined type. The Introduction is to supersede page 1 of the current (November 1984) Guideline No. 1. The remaining changes will be included as Appendix VI, a supplement to Guideline No. 1.*

**Section IV - Post-mining Fertility Assessment and Regraded Overburden Monitoring and Suitability Assessment**

A. The success of the methods employed to mitigate the impacts of toxic, acid-forming or vegetative retarding materials will be assessed through a regraded overburden monitoring program. Each applicant should submit as part of the Reclamation Plan, a detailed monitoring program to include grid spacing, parameters to be tested, sampling patterns to delineate any unsuitable areas, *resampling to verify initial results, additional sampling to delineate the area of influence* and mitigation measures to be employed. *The area of influence is generally the area surrounding the sample location. Sample locations are generally determined on a grid spacing ranging from 250 to 500 ft. centers. It is often half the distance between the sample location and the closest samples in all directions from this sample location. The areas of influence are represented by polygons or rectangles (squares) that surround the sample location.* Sample composites should not exceed a 2-foot maximum depth and sampling should be completed to a minimum of 4 feet. Visual assessment as well as organic carbon analysis should also be conducted to determine the occurrence of carbonaceous or coaly material. Before topsoiling, the operator shall request Land Quality District approval to topsoil any area which has been backfilled and regraded to final contour.

B. **Organic Carbon**

As the regraded spoil monitoring program is conducted, the entire site should be visually assessed for the presence of coal and/or carbonaceous wastes. If these wastes are seen, the operator should take action to cover these wastes with four feet of suitable materials or sample the area to determine the suitability. Carbonaceous material is defined by an organic carbon content of 10% or more as measured by the method referenced in Table I-1. The numerically defined limit protects all parties involved from incorrect designations.

C. Following spoil contouring and topsoil replacement, soil sampling and testing should be conducted to determine the fertility of the replaced material. The nutrient status of the replaced soil (parameters listed in column 1 of Table I-3, Appendix I) and the nutrient requirements of the vegetation species being planted should be considered when determining fertilizer application rates. Each reclamation plan should include a tentative post-mining sampling plan indicating methods and intensity of sampling. (A sample should be a composite to two feet of depth.)

*D. An extractable selenium level of 0.3 to 0.8 ppm will be considered marginally* *unsuitable in the upper four feet of the reclaimed spoil surface. Selenium levels in this range may show vegetation selenium levels greater than 5 ppm. This relationship was suggested in a five-year study completed jointly by the Wyoming Department of Environmental Quality, the Wyoming Mining Association, and the University of Wyoming, and is described in the Subcommittee on Soils, Vegetation, Overburden, and Wildlife position paper on selenium (Spackman et. al., 1996).*

*Operators will follow permit-approved spoil sampling programs. For example, assessment for backfill chemical parameters* ***could*** *include taking samples from 0-2 and 2-4 feet on 500-foot centers. When assessment of the rooting zone suggests extractable selenium is marginally unsuitable for an area, the operator may choose to either mitigate the problem by approved methods (capping, removal, etc.) or sample the vegetation for levels greater than 5 ppm at bond release. Vegetation sampling for marginally unsuitable selenium should only occur if the total area of influence of the spoil samples is greater than or equal to 25 percent of any bond release unit or pasture, or 40 contiguous reclaimed acres. Contiguous means those areas of influence that have a common side within the sample grid design.*

*If required, vegetation sampling shall be completed by methods as set forth in the University of Wyoming publication MP-77, Standard Operating Procedures for Sampling Selenium in Vegetation (Vegetation SOP) by Steward, et. al., (1994). One vegetation sample for each marginally unsuitable area shall be sampled within the area of influence. Modifications and items to note from this Vegetation SOP include the following:*

1. *The vegetation sampling quadrate may be randomly placed within the spoil sample area of influence, instead of adjacent to the spoil sample location as specified in the Vegetation SOP.*

2. *The vegetation sampling quadrate should be one meter square, with all vegetation collected from within the quadrate clipped for analysis as one sample. Shrub clipping should only include the current year's growth as suggested in the SOP.*

3. *Vegetation sampling should be done during the spring or growing season as described in the Vegetation SOP. Post-growing season samples will not be necessary for this bond release investigation.*

4. *During vegetation sampling, two unpalatable selenium indicators, a woody aster (Xylorhiza glabriuscula) and two-grooved milkvetch (Astragalus bisulcatus) should be excluded, if the sample site includes either of these two species.*

*Once vegetation sampling has been conducted, mitigation shall be required if the total area of influence of vegetation samples with levels of selenium greater than 5 ppm are greater than or equal to 25 percent of each bond release unit or pasture, or 40 contiguous acres of reclaimed land. The area of influence of each vegetation sample shall be the same as the area of influence of the corresponding spoil sample collected before soil replacement.*

*If an operator is required to mitigate at the time of bond release, options available to the operator include but are not limited to the following: use of mowing or farming to decrease selenium levels, exclusion fencing, or additional fencing to separate selenium tracts of greater than 40 contiguous acres of reclaimed land. Choice of options should be approved by the WDEQ/LQD before mitigation proceeds.*

*The final bond release criterion of 5 ppm selenium in vegetation is based on a level set in 1976 by the National Resource Council. Recent work in Wyoming may show this is a conservative threshold estimate. Additional studies and scientific methods of assessing deleterious effects of selenium on livestock and wildlife should be evaluated as new data becomes available.*

## ***References***

*Spackman,L.K., D.G. Steward, G.F. Vance, L.E. Vicklund, J.G. Luther, and M.F. Raisbeck. April, 1996. Interpretation of Selenium Research for Regulatory Application, Joint Subcommittee on Selenium in Soils, Vegetation, Overburden, and Wildlife. Available for review from the Campbell County Library in Gillette or from the WDEQ/LQD office in Cheyenne.*

*Spackman, L.K., G.F. Vance, L.E. Vicklund, P.K. Carroll, D.G. Steward, and J.G. Luther. 1994. Standard operating procedures for the sampling and analysis of selenium in soil and overburden material. Res. Publication. MP-82, Agric. Expt. Sta., University of Wyoming, Laramie, WY. 13pp.*

*Steward, D.G., J.G. Luther, P.K. Carroll, L.E. Vicklund, G.F. Vance, and L.K. Spackman. 1994. Standard Operating procedures for sampling selenium in vegetation. Research Publication MP-77. College of Agriculture, University of Wyoming, Laramie, WY. 6pp.*

Parameters, Analytical Procedures and Suitability Criteria for Topsoil and Overburden Analyses and Evaluation.

**Table I-1: Recommended procedures for analyzing soils and overburden/interburden quality for surface coal mines**

| | Parameter | | | Recommended Procedure | |
|---|---|---|---|---|---|
| | Topsoil | Overburden/ Interburden | Reported As | Extractant | Analytical |
| 1. | pH | pH | Hydrogen ion activity | USDA Handbook 60, method (2), pg. 84 (saturated paste). | USDA Handbook 60, method (21a), pg. 102 |
| 2. | Conductivity | Conductivity | mmhos/cm @ 25 c | USDA Handbook 60, method (3a), pg. 84. | USDA Handbook 60, method (3a), pg. 84 and method (4b), pg. 89-90 |
| 3. | Saturation | Saturation | Percent | | USDA Handbook 60, method (27a) or (27b), pg. 107. |
| 4. | Particle size Analysis | Particle size Analysis | % clay, silt, sand, and very fine sand (vfs=0.05 - 0.1 mm) | | ASA Mono. No. 9, Pt. 1 method 43-5, pgs. 562-566. Sieve analysis for very fine sand. |
| 5. | Texture | Texture | USDA textural class | | USDA Handbook 18, pgs. 205-223. |
| 6. | Soluble Ca, Mg, and Na | Soluble Ca, Mg, and Na | meg/1 | USDA Handbook 60, method (3a), pg. 84. | USDA Handbook 60, method (3a) pg. 84. Analysis by AA or ICP. |
| 7. | Sodium-absorption ratio | Sodium-absorption ratio | SAR Calculated from soluble Ca, Mg, and Na concentrations | | Calculated: USDA Handbook 60, pg. 26. |
| 8. | Carbonates | | Percent | | USDA Handbook 60, method (23c) pg. 105. |

| | | | | | |
|---|---|---|---|---|---|
| 9. | Selenium | Selenium | ppm to a lower detection limit of 0.01 | ASA Mono. No. 9, Pt. 2 (1st Ed.), method 80-3.2 pg. 1122 or ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55. | For hydride generation, pretreat extract according to ASA Mono. No. 9, Pt. 2, method 3-5.5.4, pg. 61. Hydride generation for AA (U.S. EPA, 1979) or ICP by ASA Mono. No. 9, Pt. 2 method 3-5.5.3. pg. 60. **See also UW Publication MP-82, *Standard Operating Procedures for the Sampling and Analysis of Selenium in Soil and Overburden/ Spoil Materials*, 1994.** |
| 10. | Boron **1/** | Boron | ppm | ASA Mono. No. 9, Pt. 2 method 25-9.1, pg. 443. | ICP or ASA Mono. No. 9, Pt. 2, Method 25-5. pg. 435. |
| 11. | | Nitrate-Nitrogen | ppm | ASA Mono. No. 9, Pt. 2, method 33-3.2, pg. 649. | ASA Mono. No. 9, Pt. 2, method 33-8.2, pg. 679. |
| 12. | Organic Matter | | Percent | | ASA Mono. No. 9, Pt. 2 method 29-3.5.2, pg. 570. |
| 13. | | Organic Carbon **2/** | Percent | | Dean (1974) |
| 14. | | Molybdenum | ppm to a lower detection limit of 0.1 | (NH4) 2CO3 (Vlek, 1975) or ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55 or ASA Mono. No. 9, Pt. 2 (1st Ed) method 74-2.3., pp. 1056-1057. | Furnace AA, ICP or ASA. Mono. No. 9, Pt. 2, (1st Ed) method 74-2, pp. 1054-1057 |
| 15. | | Acid potential (AP) | meg H/100g or % sulfur | | Sulfur furnace (Smith et al, 1974) or ASA Mono. No. 9, Pt. 2, methods 28-2.2.3, pg. 512-514. |
| 16. | | Neutralization potential (NP) | %CaCO3 or tons CaCO3/1000 tons material | | USDA Handbook 60, method (23c), pg. 105. |
| 17. | | Acid-base potential (ABP) | tons CaCO3/1000 tons material | | Calculated: ABP = NP - AP |
| 18. | | Arsenic **3/** | ppm | ASA Mono. No. 9, Pt. 2, method 3-5.2.3, pg. 55. or method 24-5.4, pg. 421. | Pretreat extract according to ASA Mono. No. 9., Pt. 2, method 3-5.5.5, pg. 61. Hydride generation for AA (U.S. EPA, 1979) or ICP by ASA Mono. No. 9, Pt. 2, method 3-5.5.3, pg. 60. Furnace AA also acceptable (U.S. EPA, 1979). |

| 19. | Coarse Fragment | Percent | USDA Handbook 436, App. I, Pg. 472. SCS (1972) pgs. 9 & 12-13. |
|---|---|---|---|

**1**/ Analysis recommended for mining operations in Sweetwater County, Wyoming and all bentonite operations.

**2**/ Analysis recommended for regraded coal mine spoils.

**3**/ Analysis recommended for uranium operations.

**Table I-2: Criteria to establish suitability of topsoil (or topsoil substitutes).**

| Parameter | Suitable | Marginal 1/ | Unsuitable |
|---|---|---|---|
| pH | 5.5-8.5 | 5.0-5.5<br>8.5-9.0 | <5.0<br>>9.0 |
| EC (Conductivity) mmhos/cm | 0-8 | 8-12 | >12 |
| Saturation Percentage | 25-80 | <25<br>>80 | |
| Texture | | c,sic,s | |
| SAR 2/ | 0-10 | 10-12 3/<br>10-15 | >12 3/<br>>15 |
| Selenium | *<**0.3** ppm* | *>**0.3-0.8** ppm **4/*** | ***5/*** |
| Boron | <5.0 ppm | | >5.0 ppm |
| Coarse Frag (% vol) | <25% | 25-35 | >35% |

1/ Evaluated on an individual basis for suitability.

2/ As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.

3/ For fine textured soils (clay >40%)

*4/ These marginally suitable values are keyed to sampling vegetation at bond release. Vegetation >5 ppm Se is considered unsuitable.*

*5/ No specific limit of extractable selenium concentration is provided because of the lack of data for spoil material > 0.8 ppm.*

## Table I-4: Criteria to establish overburden suitability

| | | Surface (potential root zone) | | Aquifer Restoration |
|---|---|---|---|---|
| Parameter | Suitable | Marginal 1/ | Unsuitable | Unsuitable |
| pH | 5.5-8.5 | 5.0-5.5 | <5.0 | <5.0 |
| EC (Conductivity) mmhos/cm | 0-8 | 8-12 | >12 | Depends on premining water quality and overburden quality |
| Saturation Percentage | 25-80 | <25<br>>80 | | |
| Texture | | c,sic,s | | |
| SAR 2/ | 0-10 | 10-12 3/<br>10-15 | >12 3/<br>>15 | Depends on premining water quality and overburden quality |
| Selenium **4**/ | <***0.3 ppm*** | >***0.3-0.8*** *ppm* ***5/*** | ***6/*** | Depends on premining water quality and overburden quality |
| Boron | <5.0 | | >5.0 ppm | Depends on premining water quality and overburden quality |
| Nitrate/Nitrogen | | | | >50 ppm |
| Molybdenum | <1.0 ppm | >1.0 ppm | | |
| Acid/base pot. **7/** | >-5 CaCO3 equivalent/1000 tons | | <-5 tons CaCO3 equivalent/1000 tons | <-5 tons CaCO3 equivalent/1000 tons |
| Arsenic | <2.0 ppm | >2.0 ppm | | Depends on premining water quality and overburden quality |
| Organic Carbon | <10% | | >10% | |

1/ Evaluated on an individual basis for suitability.

2/ As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.

3/ For fine textured soils (Clay 40%).

*4/ Applicable only to uplands and ephemeral drainages. The limits of spoil material suitability for other hydrologic features will be #0.1 ppm extractable Se unless the operator can verify that higher Se concentrations will not affect water quality or target organisms.*

*5/ The marginal value for selenium is keyed to sampling vegetation at bond release. Vegetation >5 ppm Se is considered unsuitable.*

*6/ No specific limit of extractable selenium concentration is provided because of the lack of data for spoil material > 0.8 ppm.*

7/ Record as Acid pot., Neutralization pot. and acid-base potential in + tons CaCO3 equivalent/1000 tons.