DEPARTMENT OF ENVIRONMENTAL QUALITY

LAND QUALITY DIVISION

GUIDELINE No. 1A

TOPSOIL AND SUBSOIL

Last Revised – 8/2015

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
LAND QUALITY DIVISION (WDEQ/LQD)

GUIDELINE NO. 1A

TOPSOIL AND SUBSOIL – AUGUST, 2015

I. Introduction - This document is a guideline only. The guideline should not be interpreted as mandatory. This portion of the guideline is intended to assist all interested parties in the management of topsoil and subsoil in terms of permitting, baseline characterization, soil handling, and field verification of soil salvage and replacement. Soil is the most valuable and voluminous environmental resource to be managed in mining. Vegetation establishment and general reclamation success are enhanced by proper salvage and replacement of soil.

Permittees may propose alternative methods to achieve the basic performance standards embodied in the Wyoming Environmental Quality Act and the appropriate Rules and Regulations. However, the procedures provided in this guideline are those recommended by the WDEQ/LQD. If any permittee proposes alternative handling procedures, the WDEQ/LQD staff and permittee must achieve basic agreement that alternative procedures are acceptable before using the procedures in the field or before approval of any permitting actions. Deviations from this guideline can be included in an application based on discussions/agreements with the WDEQ/LQD staff before the application submittal. Deviations from the guideline should be documented to ensure the record file shows how and why these deviations were acceptable.

Please refer to Guideline No. 4, Attachment IX, Reference Document 6 for additional information regarding soil management at In situ Mining operations. Also, refer to Guideline 6 for **Noncoal** operations and Guideline 6A for **Coal** Operations for appropriate formatting and organization of soil information submitted for permit approval. As outlined in this guideline, Appendix D-7 is designated as the location for soil baseline information in permit applications.

An important aspect of the permitting is to understand the WDEQ/LQD permitting procedures and processes. The WDEQ/LQD Guideline 24 provides a Pre-Application Process Guideline for Permit Applications, Amendments, and Revisions for Coal and Noncoal Mining Operations. By following these suggested pre-applications meeting guidance, it will help to ensure that the application presented to the WDEQ/LQD for review is complete. It will also help reduce the review time required for approving most permitting actions by improving the quality and technical accuracy of the application before the review begins. The WDEQ/LQD Administration recommends that permittees and WDEQ/LQD staff use Guideline 24 when planning permitting actions.

DB 11/1984
Rules Update 08/1994
Se Update 11/1996
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II. Definitions – These definitions apply to both Coal and Noncoal Operations as cited.

Topsoil is defined in the Wyoming Environmental Quality Act (Statutes) as soil on the surface prior to mining that will support plant life, and is defined in the WDEQ/LQD **Coal** and **Noncoal** Rules as the A and E Horizons or any combination thereof.

Subsoil is not defined in the Wyoming Statutes, but is defined in the WDEQ/LQD **Coal** and **Noncoal** Rules as the B and C Horizons excluding consolidated bedrock material.

Soil is not defined in the Wyoming Statutes or the WDEQ/LQD Coal and Noncoal Rules. For the purposes of this guideline, the term "soil" refers to both topsoil and subsoil and is described as the 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.

Soil Substitute refers to unconsolidated material capable of supporting plant growth. This material can be found anywhere within the native in-situ profile above the product material. There is no regulatory definition for soil substitute. However, **Coal** Rules Chapter 4, Section 2(c)(ix) states that the operator must demonstrate that when a soil substitute is used for reclamation, the resulting plant growth is equal to, or more suitable for sustaining vegetation than the existing soil and that it is the best available in the permit area to support revegetation. **Noncoal** Rules Chapter 3, Section 2(c)(iii) is similar in stating that selected overburden can be used as a topsoil substitute. These rules are cited and discussed in Section IV. Soil Substitutes and Barren Area Assessment of this guideline.

Barren Areas is not defined in the Wyoming Statutes or the WDEQ/LQD Coal and Noncoal Rules. For the purposes of this guideline, the term "barren area" refers to land that did not support vegetation prior to becoming affected as stated in WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(d)(ii) and the WDEQ/LQD **Coal** Rules, Chapter 4, Section 2(d)(i)(B).

III. Soil Baseline Assessment (Coal and Noncoal Operations)

A. **Objectives for Assessing the Soil Baseline**

1. Initiate soil sampling methods and intensities;
2. Determine the physical and chemical characteristics of the topsoil and subsoil and use those characteristics to identify established USDA Natural Resources Conservation Service (NRCS) soil series or complexes, where possible;
3. Translate identified soil series, associations or complexes into appropriate mapping units;
4. Plot, on an appropriate base map, the boundaries of those mapping units;
5. Identify those mapping units and soil depths that will be salvaged for reclamation purposes and provide a discussion of the available topsoil, subsoil, or soil substitute. As noted in Section II, Definitions, the regulatory definition of topsoil is the A and E horizons and for subsoil it is the B and C horizons;
6. Estimate the volumes of soil that will be salvaged for reclamation purposes; and
7. Provide a basis for the evaluation of soil to achieve the proposed post-mining land use.

B. **Description of the Soil Baseline**

1. The soil survey should be conducted in accordance with the standards of the most recent editions of the National Cooperative Soil Survey USDA NRCS Field Book for Describing and Sampling Soil; National Soil Survey Handbook; and Soil Survey Manual.
2. USDA NRCS Soil Series information can be obtained online at https://soilseries.sc.egov.usda.gov/osdname.asp.
3. The purpose of the soil survey is to assist with the identification of all soil suitable for salvage and replacement. Therefore, those site specific characteristics of the soil that may influence salvage, stockpiling, replacement, and revegetation should be specifically noted. Appendix A of this Guideline provides recommendations for conducting soil surveys. Appendix B provides recommendations for soil sampling and analysis.

IV. Soil Substitutes and Barren Area Assessment

Some mining operations may not have sufficient topsoil and subsoil (quantity or quality) to accomplish required revegetation. When this occurs, operators may use overburden or other suitable material in the absence of suitable subsoil. However, the operator must demonstrate the soil substitute will be beneficial and is suitable for sustaining vegetation.

The primary objectives for assessing soil substitutes are to 1) estimate the volumes of substitute material that will be salvaged for reclamation purposes, and 2) provide a basis for the evaluation of the substitute material to achieve the proposed post-mining land use.

A topic related to use of soil substitutes is an operator’s ability to leave barren areas within the reclamation. Barren area reclamation is particularly applicable to bentonite mining operations where vegetation can be limited due to sodic and alkali or acid conditions. The WDEQ/LQD has determined that no revegetation is required on reclamation of barren areas on an acre-per-acre basis when compared to the premining landscape. However, specialized seed mixes can be used to establish vegetation on these poor quality materials to help stabilize these areas. It should be noted that on adjacent areas where vegetative growth may occur on the pre-mine landscape, revegetation is required. The location and acreage of barren areas must be presented in the Appendix D-7 (Soils Baseline), Appendix D8 (Vegetation Baseline), and the Mine Plan of permit applications.

Regardless of the extent of barren areas, it is important that the operators consider applying suitable surface materials over the entire disturbance, when it is available, to help maintain a stable post-mining topography and help obtain bond release. Efforts by the operator to identify and replace suitable vegetative growth media on areas that were barren pre-mine may help with landform stability and improve the area for post-mining land use. Because degradation of water or water pollution is prohibited on reclaimed lands no matter if the lands were barren pre-mine, the permittee should evaluate other earthen materials within the pit disturbance area to identify possible suitable soil substitute for replacement at the surface. Placement of suitable soil substitute will help to limit pollution, erosion, and sedimentation. It will also provide a seed bed to obtain a stable surface. Identification of substitute material can be done through baseline overburden sample data, historic sampling during exploration, and the previous experience of the operator working with material from the pit.

The following statutes, rules and regulations and supporting comments provide some of the basis and requirements for soil substitutes (these citations are grouped by **Coal** and **Noncoal** as noted below):

(Citations A., B., C. and D apply to both Coal and Noncoal Operations)

A. The Wyoming Statutes § 35-11-415(b)(iii) under the Duties of the Operator states that *the operator, pursuant to an approved surface mining permit and mining plan and reclamation plan, or any approved revisions thereto, shall protect the removed and segregated topsoil from wind and water erosion, and from acid or toxic materials, and preserve such in a usable condition for sustaining vegetation when restored in reclamation, or if topsoil is virtually nonexistent or is not capable of sustaining vegetation, then subsoil, which is available and suitable, shall be removed, segregated and preserved in a like manner as may be required in the approved reclamation plan.*

   If suitable topsoil is not available in sufficient quantity to accomplish reclamation, then suitable subsoil should be salvaged for that purpose, if available from the specific affected area.

B. Unless adequate demonstration by the operator that all or a portion of the subsoil material is not needed to meet the vegetation and land use requirements, operators are required to salvage subsoil suitable for plant-growth medium. The WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(c)(ii)(A) and the WDEQ/LQD **Coal** Rules, Chapter 4, Section 2(c)(ii)(A) state that *all subsoil determined by field methods or chemical analysis to be suitable as a plant-growth medium shall be removed from all areas to be affected and handled in accordance with the topsoil requirements in the Rules.*

   If suitable subsoil is not available in sufficient quantity to accomplish reclamation, then use of a soil substitute may be warranted as outlined below.

C. WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(d)(ii) and the WDEQ/LQD **Coal** Rules, Chapter 4, Section 2(d)(i)(B) states that *when land did not support vegetation prior to becoming affected, land need not be revegetated unless subsoil or overburden from such affected land will support vegetation. The operator shall demonstrate to the Administrator's satisfaction that revegetation or reforestation is not possible if he seeks to proceed under the provisions of this subsection.*

D. As stated in the **Coal** and **Noncoal** Rules and Regulation citation listed in C. above, barren areas do not need to be revegetated; however, all reclamation must be stable to prevent substantial erosion and does not pollute waters of the state. The Wyoming Statutes §35-11-402(vi) states that *mining operations must prevent pollution to waters of the state, substantial erosion, sedimentation, landslides, accumulation and discharge of acid water, and flooding during and after mining and reclamation.*

(Citation E applies to Coal Operations)

E. The WDEQ/LQD **Coal** Rules, Chapter 4, Section 2(c)(ix) states that *if a sufficient volume of topsoil or subsoil is not available for salvage or redistribution, then selected spoil material may be used as a topsoil or subsoil substitute or supplement. The operator shall demonstrate that the resulting plant growth medium is equal to, or more suitable for sustaining vegetation than existing topsoil or subsoil and that it is the best available in the permit area to support revegetation.*

(Citation F. applies to Noncoal Operations)

F. WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(c)(iii)(A) states that *if insufficient suitable topsoil or subsoil is available for salvage or redistribution, then the operator may use selected overburden as a topsoil substitute. The operator shall demonstrate by analysis or test plots that the substitute material is suitable as an alternative material.*

V. Soil Salvage

Soil salvage is an essential and critical step in the reclamation process because soil provides the best material for revegetation. The salvaged material, once replaced, provides the foundation for plant growth which is necessary for reclamation success. The fundamental approaches to soil salvage should consider the following:

A. Soil salvage is required for both **Coal and Noncoal Operations**. This includes the salvage of suitable topsoil and subsoil consistent with the permit. Topsoil is often mixed with subsoil in the salvage process (Coal Rules and Regulations, Chapter 4, Section 2(c)(i)(A) and Noncoal Rules and Regulations, Chapter 3, Section2(c)(i)(A)), with the resulting mix becoming "soil" as defined in Section II above.

B. For **Coal Operations** as required by the Coal Rules and Regulations, Chapter 4, Section 2(c)(iii), when deemed necessary by the Administrator to achieve revegetation success, topsoil shall be segregated from subsoil in the salvage process.

C. For both **Coal and Noncoal Operations**, soil salvage may occur in a manner whereby topsoil is segregated from subsoil. All operators and the WDEQ/LQD staff are encouraged to investigate the literature to become educated on this practice and determine if it is useful for achieving successful reclamation at specific operations. To meet the requirements outlined in B. above, Coal Operators may be requested, under specific site conditions where topsoil is more than one to two inches thick, to provide an evaluation of the topsoil and subsoil and how mixing these soils will affect the quality of the reclamation (Coal Rules and Regulations, Chapter 4, Section 2(c)(iii)). The WDEQ/LQD understands that this segregation is not always practicable because of thin topsoil in Wyoming's arid environments.

In developing permit applications, it is recommended that the applicant include in the Mine Plan, a description of how the operator proposes to ensure salvage of all suitable soil. The plan would include:

(Recommendation A. and B. below apply for both Coal and Noncoal Operations)

A. Monitoring and supervision of soil salvage activities in the field by properly trained personnel to ensure salvage of all suitable soil;

B. Placement of stakes or other markers showing soil depth for salvage may be used as a visual reference for equipment operators as the soil is salvage. Visual indicators may be used to guide salvage operations. This method will help ensure that all soil is salvaged according to the soil survey and baseline information. Once the soil has been salvaged, a check of the baseline information can be made to determine if the baseline soil salvage depth as predicted in the soil survey account for actual field salvage depths;

(Recommendations C., D, and E. below apply to Coal Operations)

C. Islands of soil or pedestals may temporarily be left for inspection purposes to help verify salvage depths (a minimum of one pedestal per five acres or on 500 ft. grid centers are often left for inspections; specifics on leaving pedestals and their spacing are included as commitments in the approved permits);

D. Operators considering reducing subsoil salvage should incorporate the information discussed in Appendix E of this guideline into the permit.

E. Special handling of materials for plant growth and hydrologic function may be required to recreate or restore Alluvial Valley Floors, Wetlands, or Playas. Each operator should consult with the Land Quality Division staff on proper salvage, storage, and replacement of these materials in order to reestablish the function of these features. If special handling of these materials is required, then specific commitments will be necessary in the permit applications.

VI. Volumetric Presentation

The citation below describes that an operator must provide a plan for soil salvage and replacement. In order to evaluate that plan, the operator must present the volume of soil available for salvage in the Mine Plan and associated soil replacement in the Reclamation Plan including the depth of soil to be replaced.

For both **Coal and Noncoal Operators**, the WDEQ/LQD **Noncoal** Rules, Chapter 2, Section 2(b)(iii)(A) and the WDEQ/LQD **Coal** Rules, Chapter 2, Section 6(b)(i) *require a plan for topsoil and subsoil removal, storage, protection and replacement that shall include a description with location maps and, where appropriate, typical topographic profiles of the mine facility area, mineral stockpiles, spoil piles, and topsoil and subsoil stockpiles. The location, and where required, the capacity of each stockpile shall be described and shown on a map. The application shall also explain how the topsoil will be replaced on the affected land during reclamation, including a description of the thickness of topsoil to be replaced and the procedures that will be followed to protect the topsoil from excessive compaction and wind and water erosion until vegetation has become adequately established.* .

For both **Coal and Noncoal Operations** data derived from the soil survey and analyses should be evaluated to estimate the volume of soil that will be salvaged and be available for reclamation. In this evaluation, the following should be presented (Appendix C of this guideline provides several example tables for information to be provided in Appendix D-7 of the permit applications):

A. Soil salvage maps (same scale as soil survey map) should be presented showing the salvage depth(s), soil salvage sequence, and the areas to be affected. This information may need to be presented on more than one map to improve legibility and limit clutter (see Appendix C, of this document);

B. In the Appendix D-7 of the permit applications, operators should include a table similar to Appendix C, Attachment C-1. Permits should include a table that lists the following:

    1. The acreage of each mapping unit where soil salvage is planned;

2. The average depth of soil to be salvaged for each mapping unit;
3. The volumes of soil to be salvaged from each mapping unit.

C. In the Mine Plan of the permit application, the following information should be included:

For **Coal operations**, the life of the mine estimates of total soil volumes and acreages disturbed should be presented for each year of the current term of permit and in five year increments thereafter. For multiple pit coal mines, it may be more appropriate to present soil volumes based on a pit-by-pit basis.

For **Noncoal operations**, estimates for total soil volumes and acreages disturbed should be presented every year for the life-of-mine.

D. Annual Reports - For both **Coal and Noncoal** operations, the appropriate Annual Report Format should be used for reporting this information.

VII. Soil Replacement

Soil replacement is a critical and key step in the process for successful reclamation. Replaced soil is the foundation for revegetation. Standards have been established for the replacement of soil through years of reclamation and field studies. Below are factors that the WDEQ/LQD considers to be important for soil replacement.

For both **Coal and Noncoal Operations**, the average soil replacement depth should be consistent with the criteria established in the approved permit. The estimated average and range of soil replacement depth should be specified. The soil replacement average should be used in association with the soil volumes to track the amount being replaced over time. This tracking is important to ensure that there is no soil surplus or deficit as reclamation progresses. Long-term tracking of the average soil replacements will help to ensure that all the soil is being used as outlined in the Reclamation Plan. As stated in the Coal Annual Report Format (CARF), recovery efforts that are consistent with the baseline predictions verify that the calculated replacement depth is appropriate. The soil recovery trends that are inconsistent with permit predictions over multiple years must result in a recalculation of appropriate soil replacement depths via a permit revision. Obtaining the target average soil replacement is especially important as the mine approaches the end-of-mine timeframe.

Some studies performed in the western areas of the U.S. showed that revegetation results are affected by various soil depths (Buchanan et al., 2005, Bowen et al. 2005, Schladweiler at al., 2005, Williams et al, 2002). Deeper or shallower soil depths favor different vegetation communities. This association between soil depth and plant communities should be considered during reclamation planning when determining the seed mix. Although variable soil replacement depths are not required, each operator may wish to consider variable soil replacement depths on a site-specific basis in the development of their Reclamation Plans to enhance the desired post-mining land use.

It is recommended that operators consider "direct haul" replacement when practicable, as long as soil replacement depths outlined in permit commitments are not exceeded. This method incorporates salvage and hauling of soil to replacement areas in a single step, without stockpiling. Research indicates that direct-haul soil can result in higher mycorrhizae levels, better physical characteristics, and a slightly greater potential for seed bank benefits compared to reclamation where soil has been hauled from stockpile (Schuman, 2002). Although direct haul can supply a viable seed source for native vegetation adapted to the mine site, it should be noted that soil containing infestations of weeds or undesirable vegetation species such as Cheatgrass may not be appropriate for direct haul replacement. Direct haul is discouraged when salvaging soils with thick introduced annual grass cover, where chemical control methods often do not restrict re-infestation resulting from soil seed banks.

For **Coal Operations** the following outlines specific criteria for soil replacement depths:

A. Operators are required to replace topsoil at a uniform depth with some flexibility allowing variations in soil replacement depths when it helps revegetation goals as required by the Coal Rules and Regulations, Chapter 4 Section 2 (c)(v) *Topsoil, subsoil, and/or an approved topsoil substitute shall be redistributed in a manner that: (A) Achieves an approximately uniform, stable thickness consistent with the approved permit and the approved postmining land uses, contours and surface water drainage systems. Soil thickness may also be varied to the extent such variations help meet the specific revegetation goals identified in the permit.*

B. Previously, 30 CFR 816.22 of the Federal regulations was revised to allow coal mining operators to apply topsoil at variable depths. Subsequently, in 2012 the WDEQ/LQD Coal Rules and Regulations were also revised to allow the variable soil replacement depth as noted above. The average and range of the soil replacement depth should be specified in each permit. If variable depth replacement is proposed, clear justification should be presented as outlined in Appendix D of this guideline.

   When variable soil replacement depths are approved in the permit for reclamation, the requirement remains to salvage and replace all suitable soil. Variable depth of subsoil or soil can be approved based on site specific conditions. A stated average and range for all soil replacement depths should be provided to ensure the soil resource is used in its entirety during the life-of-mine.

C. Operators considering reducing subsoil (soil) and replacement depths should incorporate the information discussed in Appendix E of this guideline into the permit. In each soil replacement scenario, an average replacement depth must be justified with appropriate salvage depth data and discuss anticipated environmental benefits resulting from a reduced subsoil or soil replacement depths.

D. The assessment and confirmation of soil replacement depths occurs as part of the inspection process. The inspector has several options available to assess soil replacement depths including observations of the soil replacement operation, checking the edge of the soil laydown area, auger drilling within the soil replacement areas, or checking marked lathe/stakes within the soil replacement units. The results of the soil replacement confirmation can be summarized and verified via the Annual Report or as an independent Soil Depth Verification package (Guideline No. 22). Procedures for verifying soil replacement depths are also outlined in WDEQ/LQD Coal Standard Operating Procedure entitled "Compliance Assessment Methods and Records for Soil Replacement Performance Standards and Associated Permit Commitments During Land Quality Division Compliance Inspections" (Coal SOP 5.2).

For **Noncoal operations**, the WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(c)(i)(E) states that *topsoil, or an approved substitute, shall be distributed at an approximate uniform depth on the surface of all lands affected consistent with the approved permit and the postmining land use*. Therefore, variable soil replacement depths are allowed on Noncoal operations when the variable soil depths assists in attaining the postmining land use. In addition, all suitable soil must be salvaged (up to 60 inches) and replaced. The average and range of soil depth replacement should be specified in the Mine and Reclamation Plans. Inspections are used to ensure all soil is salvaged and replaced.

VIII. Postmining Soil Fertility and Quality Assessment after Reclamation

For both **Coal and Noncoal operations**, there may be instances after initial establishment when the vegetation declines to the point where revegetation success requirements cannot be met. Unless barren areas were present before mining and approved for the postmining landscape, adequate vegetation must be established according to the WDEQ/LQD Rules and Regulations in order to obtain bond release. The cause of any unacceptable vegetation performance should be determined before reseeding is attempted. Characterization of the regraded surface profile may be beneficial to determine if certain areas of the rooting zone are inhibiting root growth. Additionally, sampling may be necessary to determine if a specific parameter or zone is causing phytotoxic conditions. The operator should use Appendix B and the criteria outlined in **Attachment B2** of this guideline to sample and determine what constituent might be causing the problem. Under such circumstances it is recommended that sampling be done on one acre grids.

For **Noncoal operations**, WDEQ/LQD **Noncoal** Rules, Chapter 3, Section 2(c)(i)(C) and the WDEQ/LQD **Coal** Rules, Chapter 4, Section 2(c)(i)(C) state *that reclamation shall follow mining as soon as is feasible to minimize the amount of time topsoil must be stockpiled. Where topsoil has been stockpiled for more than one year, the operator may be required to conduct nutrient analyses to determine if soil amendments are necessary* at the time this soil material is used for reclamation. **Attachment B3 of Appendix B** provides parameters and methods of analysis for fertility determination of soil on reclaimed lands.

Note that current reclamation practices do not encourage the use of fertilizers as their use often results in an increase of annual weeds and any benefits are not sustainable.

IX. Soil Erosion and Sediment Control

This section applies to both **Coal and Noncoal operators**. Soil must be protected from loss, contamination, and erosion during mining activities, including salvage, stockpiling, and replacement activities. Applicable rule and regulations are as follows:

A. The WDEQ/LQD **Noncoal** Rules Chapter 3 and **Coal** Rules Chapter 4, Sections 2(c)(i)(B) require protection of stockpiled topsoil from wind and water erosion, compaction and contamination by acid or toxic materials.

B. Following reapplication of topsoil, WDEQ/LQD **Noncoal** Rules Chapter 3, Section 2(d)(iii) and **Coal** Rules Chapter 4, Section 2(d)(i)(C) require that *after backfilling, grading and contouring and the replacement of topsoil, and/or approved substitutes, revegetation shall be commenced in such a manner so as to most effectively accommodate the retention of moisture and control erosion on all affected lands to be revegetated*.

C. WDEQ/LQD **Noncoal** Rules Chapter 3, Section 2(d)(iv) and **Coal** Rules Chapter 4, Section 2(d)(i)(F) state that *any rills or gullies that would preclude successful establishment of vegetation or achievement of postmining land use shall be removed or stabilized*.

Appendix G of this guideline, in addition to Guidelines No. 13, Sediment Ponds, and No. 15, Alternative Sediment Control Measures outline measures for soil erosion, sediment and runoff control.

X. References

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Appendix A. Soil Survey Methods

Both Coal and Noncoal Operations (unless specified otherwise)

The soil survey should be conducted in accordance with the standards of the Field Book for Describing and Sampling Soils; National Soil Survey Handbook; and Soil Survey Manual, Natural Resources Conservation Service (NRCS).

I. **Purpose -** The purpose of the soil survey is to assist with the identification and salvage of suitable topsoil and subsoil material in the design of an appropriate mine and reclamation plan. Therefore, those site specific characteristics of the soil that may influence soil salvaging, stockpiling, or re-spreading and revegetation should be specifically noted.

II. **Soil Survey Orders** are defined in the following table:

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 are 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 and traversing and some observations. Boundaries are plotted by observation and interpreted by remotely sensed data and verified with some observations.

III. **Maps**

A. The soil survey should cover the entire permit area.

1. **For Coal Mines,** Lands to be affected through mining or related activity should be intensively mapped (Order 1/Order 2). Those areas that will not be affected do not need to be mapped as intensively. However, even though an Order 3 survey is suggested for those areas that won't be disturbed, it is recommended that an Order 1/Order 2 survey be done within the entire permit area as the more intensity survey will be necessary if these areas are to ever be disturbed. Often the short-term planning does not accurately predict future mining areas.
2. **For Noncoal Mines,** lands to be affected through mining or related activity should be mapped at an Order 1 / Order 2 level and an Order 3 level non-affected areas and access roads. The surveys should be intensive enough to delineate salvage depths for each mapping unit.

B. Topographic maps or aerial photos can be used as base maps for the soil survey. A scale of 1" = 400' - 700' is desirable, but is dependent on the size of the area mapped. The map scale should be of sufficient detail to allow ease of identification of the smallest acreage of soil series mapped. The large **coal mines** have recently used map scales of up to 1"=1500' in order to get all the information on one map. The vegetation and soil maps should be the same scale as outlined in Guideline 6 and 6A.

C. The operator has the option of providing separate soil-salvage maps or placing the salvage depths on the soil survey maps. If the single map set is chosen, the permit mine plan should clearly reference this fact. The symbolism on the map should include mapping unit identifier, corresponding soil phase or series name (a soil phase is generally a subdivision of a soil type that differentiates steepness in slope, depth to bedrock, etc.), mapping units, and average salvage depth. For example:

Identifier	Series or Complex	Salvage depth
Lo	Louviers Clay	18 inches
Gr-Qu	Grummit-Querc Complex	8 inches

If separate maps are utilized then a soil salvage-depth map for the affected lands, based on a topographic map or aerial photo, should be included at the same scale as the soil survey map. Also note that it is not necessary to put a slope percentage on each map unit. This designation is more reflective of the existing NRCS mapping and map units, but not necessary for D-7 purposes.

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 (or 6A), including north arrow, legend, permit boundaries, etc.

IV. 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. Useful internet addresses containing soil series classification, soil profile descriptions, mapping unit descriptions, etc. are as follows:

http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/class/
http://www.xmarks.com/s/site/www.statlab.iastate.edu/soils/nsdaf/ , and
http://www.sdvc.uwyo.edu.

B. NRCS surveys (generally Order 3 surveys) may be used, but additional soil sampling, refinement, and modification of the mapping 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), individual soil series or consociations of a minimum size of two acres should be delineated.
2. If soils are similar (i.e., low contrasting in physical and/or chemical properties and/or depth), 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, i.e., the individual components are less than two acres in size.

D. Mapping units for lands not to be affected should consist of no less than associations and some consociations and complexes (Order 3). Dissimilar component series of associations should be delineated into consociations when the dominant individual series occur as units of 20 or more acres (representing at least 50% of the acreage) and inclusions of dissimilar soil represent less than 10% of the total area. It is possible for the number of dissimilar inclusions in a given map unit delineation to exceed 10% if no practical advantage would be obtained by defining a new map unit.

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 using existing NRCS soil series, where possible. The local NRCS soils 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.

G. If barren/outcrop areas will be replaced on reclaimed lands (**Coal** Rules and Regulations, Chapter 4, Section 2(d)(i)(B)and **Noncoal** Rules and Regulations, Chapter 3, Section 2(d)(ii)), then these areas should be mapped carefully. Since soil is generally unsuitable in these areas, it is important the extent of these areas be documented in Appendix D-7.

H. All maps must clearly show the boundaries of all proposed disturbance areas from which soil will be salvaged.

Appendix B. Soil Sampling and Analysis

Both Coal and Noncoal Operations (unless specified otherwise)

I. Soil Sampling

A. Sampling sites should be clearly marked on the baseline soils map in Appendix D-7 of the permit application.

B. Sampling sites must be representative of the soil series being mapped, but sampling should be focused primarily on areas where soil will be removed. Operators may consider sampling soils outside the planned disturbance areas as Mine Plans do change over time. The number of sampling sites should adequately characterize each soil series. It is recommended 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 minimum sampling intensities for soil chemical and physical characterization are recommended for each soil series:

5% of anticipated permit area (or >160 acres)	3 sampled pedons
2-5% of anticipated permit area (or 40 to 160 acres)	2 sampled pedons
2 % of anticipated permit area (or <40 acres)	1 sample pedon

Component soils in complexes and associations should be sampled as outlined above. Additional samples may be necessary to provide information on spatial variability. Some sampling may be deferred by contacting WDEQ/LQD and developing a pre-salvage soil assessment program, and any agreement should be clearly documented.

For proposed amendment areas, the above sampling criteria should be used. However, if a soil mapping unit or soil series from the currently approved permit area is found in the amendment area, this mapping unit or soil series should be sampled and analyzed at least once in the amendment area to ensure its physical and chemical characteristics are similar to those previously identified. The number of samples needed under this type of scenario should be discussed and approved by the WDEQ/LQD before the sampling is completed.

C. A profile description should be taken for each soil being sampled. The major soil horizons (A, E, B, and C) should be separately described, sampled, and analyzed. If sub-horizon delineations occur within any major horizon, these should also be separately analyzed. Where a major soil horizon is more than 12 inches thick in the upper part or more than 18 inches thick in the lower part (below 2 feet) of the profile, these horizons should be subdivided and sampled. Soil profiles should be sampled to sixty inches or bedrock, whichever occurs first. When material below sixty inches is suspected of being soil material suitable for reclamation, sampling should continue through the depth of this material if soil is limited (to less than 18 inches average depth per acre) elsewhere at the mine site. The soil scientist conducting the survey should have an overall perspective of the soils at the proposed site to determine if additional soil salvage may be necessary from the deeper areas. Pre-baseline discussion with WDEQ/LQD staff is encouraged to determine if sampling soils to depths greater than 60 inches is warranted and any agreement should be documented.

II. Soil Sample Preparation and Analysis

Sufficient quantities of soil for each sample should be placed into clean polyethylene bags and transported to the laboratory as soon as possible. The chemical laboratory should be contacted to determine the amount of sample needed for the desired analyses and to discuss sample preservation and transport. Samples should be kept cool and not be exposed to high temperatures.

Attachment B1 lists the recommended analytical procedures for each parameter. Other procedures may be used if they provide comparable results. However, any changes in procedure listed in this guideline must be documented and included with the laboratory results. Attachment B2 lists suitability levels for each parameter.

III. Data Presentation for WDEQ/LQD Submittal

All analytical results should be presented in a tabular form by soil depth and referenced to the mapping unit, soil series, sampling site locations, and soil horizon. To ensure quality data, the following Quality Assurance/Quality Control information should be provided:

- the name of the laboratory conducting the analyses;
- sampling dates, sample location;
- dates of analyses;
- sample number;
- analytical job number; and
- a list of all methodologies utilized and their references.

Any modification to the referenced methods must be clearly reported with the sample results. This information would generally be supplied by the laboratory.

Attachment B1

(Note: These procedures need to be further reviewed/evaluated and the table updated as needed)

Procedures for Analyzing Topsoil and Subsoil Quality for Coal, Uranium and Bentonite Mines

Recommended Procedure

Parameter		Reported As	Methods of Extraction and Analysis	References[1/]
1.	pH	Hydrogen ion activity	USDA Handbook 60, method (2), (saturated paste). Extraction: Saturated paste analysis: pH meter	USDA Handbook 60, method (21a), pg. 102. Method S-1.00, pg 12 and Method S-1.10, pg 15 (Miller et al., 1998).
2.	Conductivity	mmhos/cm @ 25 c	USDA Handbook 60, method (3a). Extraction: Saturated paste Analysis: Conductivity meter	USDA Handbook 60, method (3a), pg. 84 and method (4b), pg. 89-90 Method S-1.00, pg 12 and Method S-1.20, pg 16 (Miller et al., 1998).
3.	Saturation	Percent	Extraction: Saturated paste and vacuum filter	USDA Handbook 60, method (27a) or (27b), pg 107. Method S-1.00 (Miller et al., 1998).
4.	Particle size Analysis	% clay, silt, sand	Analysis: Hydrometer Method	ASA Mono. No. 9, Pt. 1 method 43-5, pgs. 562-566. Method S-1.00, pg103 (Miller et al., 1998). Sieve analysis for very fine sand. ASTM Method D422.
5.	Texture	USDA textural class	Textural triangle from Hydrometer Method results	USDA Handbook 18, pgs. 205-223. Method S-14.10, pg 103 (Miller et al., 1998).
6.	Soluble Ca, Mg, and Na	meq/1	Extraction- Saturated paste extract Analysis: Atomic Adsorption (AA) or Inductively Coupled Argon Plasma (ICAP) methods.	USDA Handbook 60, method (3a), pg 84. Analysis by AA or ICP. Method S-1.00 (Miller et al. 1998). EPA method 6010-C or EPA method 200.7.
7.	Sodium-Absorption Ratio	SAR Calculated from soluble Ca, Mg, and Na concentrations	Calculation	Calculated: USDA Handbook 60, pg. 26. . Method S-1.60, pg25 (Miller et al. 1998) or Method 5E, pg 215 (NRSC, 1996)
8.	Selenium	ppm to a lower detection limit of 0.01	ASA Mono. No. 9, Pt. 2 (1st Ed.), method 80-3.2 or ASA Mono. No. 9, Pt. 2, method 3-5.2.3. Extraction: Hot water soluble or AB-DTPA. Analysis: Hydride Generation by Atomic Absorption Spectrometry for AB-DTPA extraction.	For hydride generation, EPA methods 200.7 and 6010 or 200.8 and 6020. Methods of Soil Analysis, Part 3, pg 125(Soltanpour et. al., 1996) or UW Publication MP-82 (Spackman et al., 1994).

9.	Boron[2/]	ppm	ASA Mono. No. 9, Pt. 2 method 25-9.1. Analysis: Colorimetric Method	ICP or ASA Mono. No. 9, Pt. 2, Method 25-5, pg. 435. EPA methods 200.7 and 6010, pg. 79. Method S-7.10, pg 79 (Miller et al., 1998) or Methods of Soil Analysis, Part 3, Page 613, (Keren, 1996)
10.	Organic Matter	Percent	Analysis: Titration	ASA Mono. No. 9, Pt. 2 method 29-3.5.2, pg 570. Method S-9.10, pg 83 (Miller et al., 1998) or Methods of Soil Analysis, Part 3, Page 995 (Nelson and Sommers, 1996)
11.	Coarse Fragment	Percent	Analysis: Sieve	USDA Handbook 436, App. I, Pg. 472. SCS (1972) pgs. 9 & 12-13.NRCS, 1996

1/ References

Keren, R, 1996, Boron, Chapter 2, Soil Science Society of America and American Society of Agronomy, 677 S. Segoe Rd, Madison, WI 53711. Methods of Soil Analysis. Part 3. Chemical Methods - SSSA Book Series No. 5.

Miller, Robert, O., Kotuby-Amacher, J, and Rodriguez, J.B., 1998, Western States Laboratory Proficiency Testing Program, Soil and Plant Analytical Methods, Version 4.10

Nelson, D.W. and L.E. Sommers, 1996 Total Carbon, Organic Carbon, and Organic Matter, Chapter 34, Soil Science Society of America and American Society of Agronomy, 677 S. Segoe Rd, Madison, WI 53711. Methods of Soil Analysis. Part 3. Chemical Methods - SSSA Book Series No. 5.

Soltanpour, P.N., Workman, S.M., Jones, J. B. Jr., Miller, R.O., 1996, Inductively Coupled Plasma Emission Spectrometry and Inductively Coupled Plasma-Mass Spectrometry, Chapter 5, Soil Science Society of America and American Society of Agronomy, 677 S. Segoe Rd, Madison, WI 53711. Methods of Soil Analysis. Part 3. Chemical Methods - SSSA Book Series No. 5.

National Resources Conservation Service (NRCS), 1996, Soil Survey Laboratory Manual, Soil Survey Investigations Report No. 42, Version 3.0, US Department of Agriculture, National Survey Center (Internet access - http://www.statlab.iastate.edu/soils/nssc/ssir42/ssir42.pdf)

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.

2/ Boron analysis is recommended for mining operations in Sweetwater County and for bentonite operations.

Attachment B2
Criteria to Establish Suitability of Soil or Soil Substitutes

Parameter (unit)	Suitable	Marginal [1/]	Unsuitable
pH	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 >9.0
EC (Conductivity) mmhos/cm	0-8	8-12	>12
Saturation Percentage (%)	25-80	<25 >80	
Texture		c,sic,s[2]	
SAR [3/]	0-10	10-12 [4/] 10-15	>12 [4/] >15
Selenium (ppm)	<0.3	>0.3-0.8[5/]	
Boron (ppm)[6/]	<5.0		>5.0
Coarse Frag (% Vol.)	<25	25-35	>35

1/ Evaluated on an individual basis for suitability;

2/ Clay (c), sic (silty clay), s (sand);

3/ As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined;

4/ For fine textured soils (clay >40%);

5/ Preferred extraction is with AB-DPTA which extracts water soluble and exchangeable species of Se (However, hot water extractable methods are acceptable for coal mines that have historical data collected using this procedure). These marginally suitable values of 0.3 to 0.8 ppm in the regraded spoil are keyed to sampling vegetation at bond release. Vegetation >5 ppm Se is considered unsuitable. Generally, selenium is more pervasive in the spoil material compared to the soil. Please refer to Guideline 1B for specifics on sampling intensity of regraded spoils;

6/ Boron analysis is recommended for mining operations in Sweetwater County and for bentonite operations.

Attachment B3
Parameters Recommended for Determining Fertility Status of Soil on Reclaimed Land Surface. [1/]

	Parameter	Reported As	Methods of Extraction and Analysis	References [2/]
1.	Nitrate-Nitrogen	ppm	Extraction: w/ KCl and reduction to NO_2 by Cd Analysis: Colorimetric Methods	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. Methods of Soil Analysis, Part 3, Extraction of Exchangeable Ammonium and Nitrate and Nitrite & cadmium reduction and colorimetric analysis, Mulvaney, R.L. (1996), Extraction pg.1130 & Analysis pg.1155.
2.	Total Phosphorus	ppm	Extraction: w/AB-DTPA Analysis: ICP or Colorimetric	ASA Mono. No. 9, Pt. 2, method 29-3.5.2, pg 422. Kuo, S. (1996), pg 897, Ammonium Bicarbonate-DTPA Extraction.
3.	Organic Matter	Percent	Extraction: $K_2 Cr_2O_7$ Analysis: Titration Analysis: Loss on ignition	ASA Mono. No. 9, Pt. 2, method 29-3.5.2, pg 570. Methods of Soil Analysis, Part 3, Walkley-Black Method or Loss on Ignition, Nelson and Sommers (1996), pg 1001.
4.	Potassium	ppm	Extraction: AB-DTPA Analysis: Analysis by AA or ICP	ASA Mono. No. 9, Pt. 2, method 24-5.5, pg 422. Analysis by AA or ICP. Methods of Soil Analysis, Part 3, DTPA Extraction, Melmke and Sparks (1996) pg, 570.
5.	pH		USDA Handbook 60, method (2), Extraction: Saturated paste Analysis: pH meter	USDA Handbook 60, method (21a), pg 102. Method S-1.00, pg 12 and Soil and Plant Analytical Methods, Version 4.10, method S-1.10, pg 15 (Miller et al., 1998).
6.	Conductivity	mmhos/cm @ 25 degrees C	USDA Handbook 60, method (3a). Extraction: Saturated paste Analysis: Conductivity meter	USDA Handbook 60, method (3a) pg. 84 and method (4b), pg 89. Soil and Plant Analytical Methods, Version 4.10, method S-1.00, pg 12 and Method S-1.20, pg 16 (Miller et al. 1998).
7.	Soluble Ca, Mg, Na	meq/l	Extraction: Saturated paste extract Analysis: Atomic Adsorption (AA) or Inductively Coupled Argon Plasma (ICAP)	USDA Handbook 60, method (3a), pg 84. Analysis by AA or ICP. Soil and Plant Analytical Methods, Version 4.10, method S-1.00, pg12 (Miller et al. 1998).

8.	Sodium absorption ratio (SAR)		Calculation	Calculated from: USDA Handbook 60, pg 26. Soil and Plant Analytical Methods, Version 4.10, method S-1.60, pg 25 (Miller et al. 1998) or Soil Survey Investigations Report No. 42, method 5E, pg 215, (NRCS, 1996).
9.	Texture	USDA Textural class	Textural triangle from Hydrometer Method results	USDA Handbook 18, pg 205. Soil and Plant Analytical Methods, Version 4.10, method S-14.10, pg 103 (Miller et al. 1998).
10.	Particle Size Analysis	% clay, silt, sand and very fine sand (vfs = 0.05 - 0.1mm)	Analysis: Hydrometer Method	ASA Mono. No. 9, Pt. I, method 43-5 pgs. 562-566. Soil and Plant Analytical Methods, Version 4.10, method S-1.00, pg 103 (Miller et al., 1998). Sieve analysis for very fine sand.

1/ Dates of sampling and analysis should be provided.

2/ References

Helmke, P.A., and D.L. Sparks, 1996, Lithium, Sodium, Potassium, Rubidium, and Cesium, In D.L. Sparks et. al. (ed.), Methods of Soil Analysis, Part 3, Chemical Methods, Soil Science Society of Agronomy, 677 S. Segoe Rd., Madison, WI, pg 570.

Kuo, S., 1996, Phosphorus, In D.L. Sparks et. al. (ed.), Methods of Soil Analysis, Part 3, Chemical Methods, Soil Science Society of Agronomy, 677 S. Segoe Rd., Madison, WI, pg.897

Nelson, D.W. and L.E. Sommers, 1996, Total Carbon, Organic Carbon, and Organic Matter, In D.L. Sparks et. al. (ed.), Methods of Soil Analysis, Part 3, Chemical Methods, Soil Science Society of Agronomy, 677 S. Segoe Rd., Madison, WI,, pg 1001

Miller, Robert, O., Kotuby-Amacher, J, and Rodriguez, J.B., 1998, Western States Laboratory Proficiency Testing Program, Soil and Plant Analytical Methods, Version 4.10

Mulvaney, R.L., 1996. Nitrogen-Inorganic Forms. In D.L. Sparks et. al. (ed.), Methods of Soil Analysis, Part 3, Chemical Methods, Soil Science Society of Agronomy, 677 S. Segoe Rd., Madison, WI, Extraction pg.1130 & Analysis pg.1155.

Appendix C - Soil Data Presentation

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

I. Attachment C-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 soil material and volumes are presented. It is recommended that this type of table be included in Appendix D-7 of the permit application and referenced in the Mine Plan.

II. Attachment C-2 provides two examples to calculate soil volumes:

A. Determining soil depth available for replacement when the volume and acreage is known;

B. Determining volume when the acreage and depth of soil is known.

Attachment C-1. Soil Volume Summary
Example for Permit Insertion

Mapping Unit Symbol & Name	Composition of Disturbed [1]/ Acres — Acres	Composition of Disturbed [1]/ Acres — %	Composition of Mapping Unit (Should include inclusions) %	Depth of Soil (inches)	Total Volume of Soil (Yd^3)	Average Salvage Volume of Soil (Yd^3)	Salvage Depth of Soil (to nearest inch)	Limitations [2]/
1A Haverson loam	25.6	4.0	100	60+	209,067	97,608	28	SAR 15 at 28"
2B Bidman loam	76.8	12.0	90	60	563,500	563,500	60	
(Briggsdale sandy loam)			10	29	30,380	30,380	29	
44C Tassel-Shingle	44.8	7.0						
Rock outcrop			50	18	54,880	54,880	18	
Complex								
Tassel								
Shingle			25	8	12,250	12,250	8	
Rock Outcrop			25	0	0.0	0.0	0	
5A Stoneham loam	96.0	15.0	90	60	705,600	705,600	60	
(Cushman)			10	24	31,360	31,360	24	
7B Briggsdale sandy loam	140.8	22.0	95	29	528,057	528,057	29	
(Shingle)			5	12	11,433	11,433	12	
9A Ft. Collins-Ulm	70.4	11.0						
Association			50	60	287,467	287,467	60	
Ft. Collins								
Ulm			45	60	258,720	258,720	60	
(Shingle)			5	12	5,717	5,717	12	
6B Thedalund	108.8	17.0	100	24	355,413	355,413	24	
9B Cushman	76.8	12.0	100	24	250,880	250,880	24	
TOTAL	640.0	100.0			3,304,723	3,193,003	37	

( ) indicates inclusion

[1]/ area where soil salvage is planned.

[2]/ where soil salvage depth is different from the depth of soil, the limiting factor or parameter should be listed.

Attachment C-2. Soil Depth and Volume Calculations

A. To determine the depth of soil available when the number of acres on which soil will be replaced and the volume of soil are known:

$$X\ yd^3 \cdot \frac{27\ ft}{1\ yd} \cdot \frac{1\ acre}{43560\ \ sq\ ft} \cdot \frac{12\ in}{Y\ acres} = \text{Inches of Soil Available for Replacement;}$$

where X = yd^3 of soil available to replace and Y is the number of acres on which the soil will be replaced.

B. To determine the volume of soil needed when the depth of soil required to be replaced and the number of acres on which the soil be placed are known:

$$X\ \text{inches of soil} \cdot \frac{Y\ acres}{12\ in} \cdot \frac{43560\ \ sq\ ft}{1\ acre} \cdot \frac{1\ yd}{27\ ft} = yd^3\ \text{of Soil Volume;}$$

where X is the average depth of soil available for replacement and Y is the number of acres on which the soil will be replaced.

<u>Appendix D. Variable Soil Replacement Depths for Coal Mines</u>
Coal operations only

I. **Introduction -** The appendix addresses clarification of WDEQ/LQD Rules and Regulations to allow site specific variable soil replacement depths.

II. **Applicable Rules and Regulations -** The following Rule and Regulation citations are important to note as soil salvage is still required: WDEQ/LQD **Coal** Rules and Regulations, Chapter 4, Sec. 2(c)(i)(A), and Chapter 4, Sec. 2(c)(ii).

The key citation allowing variable soil replacement depth is found in WDEQ/LQD **Coal** Rules and Regulations, Chapter 4, Sec. 2(c)(v) where "*Topsoil, subsoil, and/or an approved topsoil substitute shall be redistributed in a manner that*:

> *(A) Achieves an approximately uniform, stable thickness consistent with the approved permit and the approved post-mining land uses, contours and surface water drainage systems*. ***Soil thickness may also be varied to the extent such variations help meet the specific revegetation goals identified in the permit*** *(bold text added)*;"

III. **Clarification of Applicable Rules**

A. **Restrictions –** As stated above, the rules and regulations requires that all suitable topsoil and subsoil be salvaged regardless if variable soil replacement depths are approved.
B. **Flexibility -** The Rule and Regulation, Coal Rules and Regulations Chapter 4, Sec. 2(c)(v)(A) as stated above, allows flexibility in how much soil is replaced based on revegetation goals in obtaining the post-mining land use. This regulation was amended in December, 2012 to state *"Soil thickness may also be varied to the extent such variations help meet the specific revegetation goals identified in the permit."*

IV. **Recommendations -** Approval of variable soil replacement depths (or depth ranges) should only be considered on a site-by-site basis. Variable soil replacement depths or ranges may be considered in order to help revegetation efforts and increase species diversity. To improve the re-vegetative success on variable replacement depth, the following principles should be followed: All suitable soil must be salvaged from areas to be mined and replaced within the disturbance area, unless justification is provided to not salvage all the subsoil. Operators will demonstrate that variable soil depth replacement strategy is achievable.

When variable soil depth or depth ranges are used, it is important for an operator to establish a tracking system to balance topsoil quantities. Annual Reports should present the existing volumes of all available soil materials as outlined in the Coal Annual Report Format (CARF). The soil recovery trend that is inconsistent with permit predictions over multiple years must result in a recalculation of appropriate soil replacement depths via a permit revision.

Appendix E. Soil (Subsoil) Depth Reduction for Coal Mines

Coal operations only

I. Introduction - Soil salvage and replacement is fundamental to successful reclamation. Most prairie soils in Wyoming have thin topsoil (as defined in this Guideline) which is generally only an inch or two thick. Therefore, in most mining situations all topsoil must be salvaged and replaced on the reclamation. However, subsoil thickness can vary greatly from one soil type to the next. The Coal Rules and Regulations allow some flexibility in subsoil replacement. As a result, reduced soil replacement depths can be approved based on site specific conditions. Therefore, proposals to reduce soil salvage and replacement depths need to be consistently and thoroughly evaluated. This appendix provides a framework in which soil depth reduction proposals may be evaluated.

II. Subsoil Regulations - The following coal regulation provides a means by which operators can reduce subsoil salvage and replacement depths:

Coal Rules and Regulations, Chapter 4 Section 2(c)(ii) Subsoil.

"(A) Except as provided in (B), all subsoil determined by field methods or chemical analysis to be suitable as a plant growth medium shall be removed from all areas to be affected and handled in accordance with the topsoil requirements of this section."

"(B) Upon an adequate demonstration by the operator that all or a portion of the subsoil material is not needed to meet the revegetation and land use requirements of these regulations, the Administrator may authorize all or a portion of the subsoil to not be used for reclamation. The unused subsoil may then be regraded as overburden material and handled in accordance with the requirements of this section."

III. Strategies to Consider for Soil (Subsoil) Salvage Reduction

Soil Salvage and Replacement Reduction Based on Adequate Demonstration - Soil Organic matter (SOC) or Soil Organic Matter (SOM) content can be considered as an important suitability criteria for operators seeking reduced soil salvage depth. SOC that is ≥0.5 % or SOM that is ≥0.9 has been shown to help sustain vegetation (Ingram, L.E., et. al.2005). Any reductions of the soil salvage depth can be evaluated and based on a comparison of the relative productivity in terms of SOC or SOM for the A and E horizons versus B and C horizons.

Further demonstrations that a soil depth reduction is warranted can be in the form of scientifically designed field studies, existing reclamation plots, greenhouse studies, or other methods pre-approved by the WDEQ/LQD. The studies should be statistically sound to ensure reproducibility. The purpose of the demonstrations is to show that the proposed reduction in soil depths will sustain long term revegetation; and the seed mix and resulting plant communities will support the post-mining land use.

A. The length of a field study on reclamation should be based on science and the duration of the study should be approved by the WDEQ-LQD before it begins.
B. Field studies on reclamation areas will include the following information:

    1. Complete documentation of the range of soil replacement depths, spoil and soil quality, slope, aspect, and climatic factors;
    2. Complete documentation of reclamation procedures, soil amendments, vegetation, and management histories;

3. A study is considered successful if the performance of the reclaimed area with the reduced soil depth is comparable to the reclamation of the full soil replacement depth areas.

IV. Zero Soil Replacement - In order for a coal operator not be required to replace soil on a given area, evidence in the form of field sampling, photos, or maps should be provided on the extent, quality, and depth of surface material present in the pre-mining environment. The operator must show that no topsoil or subsoil exists from a given area that would sustain vegetation growth (W.S. 35-11-415(b)(iii)). If this is demonstrated, the operator would be allowed to recreate these pre-mining features at a 1:1 ratio in the post-mining reclamation. The material placed at the surface must be able to sustain a stable surface. One method to ensure a stable surface is to establish vegetation. The level of nutrients present in the material proposed for substitution as a plant growth media should be considered (see Attachment B2 and B3 of Appendix B) in order to determine whether additional nutrients or fertilizer amendments must be applied to the surface material as specified in Coal Rules and Regulations Chapter 4, Sec. 2(c)(vii). Soil amendments may be considered under this scenario where no soil will be replaced. The depth of suitable spoil or substitute material should also be considered for areas of zero or limited topsoil/subsoil replacement to enhance stability.

Furthermore, erosion control is a concern that must be addressed in these areas. These areas must be erosionally stable. One method to ensure stability is to establish vegetation as mentioned above. It is recommended that site specific seed mixes be developed on areas where no soil will be replaced. These seed mixes should be created to develop sustainable vegetation on surface material that have physical and chemical characteristics that are not necessarily conducive to more commonly used seed mixes. These specific seed mixes must be reviewed and approved by the WDEQ/LQD in the permit applications before use.

Other methods of erosion control must be specifically outlined, especially in areas of zero or limited topsoil/subsoil replacement. Please refer to Appendix F for further discussion on soil erosion control.

V. Other Considerations

A. If a certain soil replacement depth is proposed, for example an 18 inch uniform depth, a range of replacement depths between 13 and 23 inches or ±25% could be allowed. It is necessary to specify soil replacement in terms of minimum depths, however, the operator must also commit to an average replacement depth in the permit to ensure a surplus or deficit of soil does not occur once reclamation is completed.

B. Requests for reduction of suitable subsoil salvage depths may require "Variances for Surface Coal Mining Operations" as described in Chapter 9 of the WDEQ/LQD Coal Rules and Regulations. For instance, if suitable subsoil existed in the pre-mine and the operator proposes to eliminate the suitable subsoil or a portion of this subsoil, then this situation could be considered an experimental practice requiring public notice and comment. Under this scenario, special monitoring is required so sufficient and reliable data are collected and reported for comparison with other practices and to assure protection of the environment.

<u>Reference</u>

Ingram, L.E., G.E. Schuman, P.D. Stahl, and L. Spackman. 2005 Microbial Respiration and Organic Carbon Indicate Nutrient Cycling Recovery in Reclaimed Soils. Soil Sci. Soc. Am. J. 69:1737-1747.

Appendix F. Soil Erosion and Sediment Control
(for both Coal and Noncoal unless otherwise specified)

I. Erosion and Sediment Control - To avoid the loss of the soil resource, it is important that operators practice appropriate measures to limit wind and water erosion. Various soil erosion and sediment control techniques can be used through typical management practices during mining and reclamation activities on all disturbance areas (other methods can be considered with prior approval by the WDEQ/LQD). Areas of consideration include:

A. Seeding of the disturbed areas at the earliest appropriate season. Seedbed preparation (tillage procedures) and seeding operations should be conducted on the contour or perpendicular to the prevailing wind direction on flat or level ground according to permit commitments. Traffic must be restricted on areas that have been reseeded.

B. Drainage bottoms require special consideration. Disturbance to drainage bottoms should be avoided where practicable. Erosion control measures are essential to protect all drainages. Erosion control measures are dependent on the following: the amount of disturbance, expected flows, channel geometry and gradient, soil type, and associated conditions. A fast growing cover crop, weed free mulching, erosion control blankets, netting, mats, weed free straw hay bales, or rock check dams should be considered to minimize soil erosion and promote revegetation. In the event that any drainage is disturbed and reconstructed, a special seed mix designated for planting in drainage bottoms should be developed.

C. Long-term soil stockpiles are constructed to conserve the salvaged soil. This stockpiling is accomplished by constructing the pile with gentle side (3:1 or flatter) slopes that permits seeding with mechanical equipment, promotes revegetation, and reduces potential erosion. A toe-ditch and/or berm should be constructed around stockpiles to assist in maintaining the soil in the pile. Soil stockpiles should be seeded with an approved seed mix at the earliest appropriate season.

D. Access roads and haul roads should be designed and constructed to assure adequate drainage to protect the road surface, base, and surrounding undisturbed and reclaimed areas using best available engineering practices such as energy dissipaters, adequate ditches, and/or culverts. Turnouts or water bars should be used in ditches, where appropriate, to minimize the velocity of runoff and reduce potential ditch erosion.

II. Typical Techniques for Reducing Erosion and Controlling Sediment

To minimize soil erosion loss, the operator should expose the smallest disturbed area of land for the shortest possible time. Soil erosion control techniques should be applied as a first line of defense against site damage. They must reduce factors affecting water velocity, redirecting runoff to stable areas, dissipating rain drop energy, etc. The most important management practice in reducing soil erosion is well established vegetation cover. Other typical erosion control techniques include: land grading (slopes), surface roughening, mulching (e.g. hydromulching, rock mulching), erosion control blankets, soil binders (stabilizers) and tackifiers. This list is not all encompassing. Other techniques may have merit and should be discussed and approved in the permits by the WDEQ/LQD before installing. If erosional rills and/or gullies develop that preclude successful establishment of vegetation or achievement of postmining land use, it should be removed or stabilized.

To prevent sediment including soil from leaving an eroded area, the operator has the option to use various techniques. Typical examples include: sediment ponds, sediment traps/sumps, rock check dams, rock riprap, gabion drop structures, straw bale barriers and wattles, continuous berms, silt fences, and channel lining. These are temporary control measures and need to be maintained (cleaned out, repaired, replaced, etc., as necessary) on a regular basis and removed when sufficient vegetation cover is established.

For coal, approval of Surficial Stability and Vegetation Establishment Verifications are necessary before removal of primary sediment control. Refer to Guideline No. 20 and 23 for further information on bond release for coal mines. Also note that the Alternative Sediment Control Measures (ASCM) described in Guideline No. 15 for coal operations can be used to protect soil resources and control sediment from leaving disturbed areas.

A. Typical Erosion Control Techniques

Vegetation seeding can help with erosion control as follows:

- Establishment of vegetation cover (e.g., permanent vegetation, temporary vegetation, cover crop, etc.) assists in reducing the surface velocity of wind and running water. The roots of established vegetation trap and hold soil particles while having a positive influence on soil porosity, water infiltration, and nutrient cycling.
- In addition to stability, cover crops can be used to stabilize the soil surface, introduce and improve nutrient cycling in the soil to positively affect microbial activity. Cover crops generally consist of annual crops such as wheat, barley, oats, rye or millet which are planted before permanent seeding. Warm season plant varieties may be best suited for use as green crops to improve soil nutrient and moisture conditions.
- In addition, cover crops can be disced into the soil and act as green manure for adding nutrients to the soil or left as standing stubble before final seeding. In some cases, one negative aspect of cover crops, especially during prolonged droughts, is the potential for reduced soil moisture for other plants thus affecting establishment of a permanent vegetation cover.
- Nurse crops (seeded at a rate of <5 pounds of pure live seed (pls) per acre) are rapidly growing annual grains seeded with the temporary or permanent seed mix for quick soil stabilization and minimal competition for moisture.
- Rangeland no-till drilling is recommended to seed the permanent seed mix into cover crop stubble.

Other surface techniques can be helpful for surface stabilization as follows:

1. Land grading (slopes). Graded slope steepness to a ratio of less than 4:1(run/rise) should minimize development of erosional features. Shorter and flatter slopes are less erodible. The most stable slope profile is complex (convex in the upper portions and concave along the lower portion of a slope).
2. Surface roughening should be performed on the contour when possible to create a series of ridges and depressions that run across the slope. Seed bed preparation can include pitting or other rough surface features to reduce the various types of surface erosion.
3. The WDEQ/LQD strongly recommends mulching following seeding. Mulch can be organic (plant material) or inorganic (rock, gravel). Weed free straw and native grass hay mulch temporarily stabilizes the surface and prevents erosion. Mulching increases the moisture of soil, insulates the seed and seedlings against extreme climate conditions, and provides additional input of organic matter and nutrients into the soil. Generally, organic mulching is effective for two to five years before decomposing. Caution should be taken to avoid introducing weeds with mulching.
4. Rock mulching may help stabilize the soil surface and reduce evaporation. The operator may consider using rock, if it existed on the surface in the pre-mining landscape, to complement mulch to control erosion. Rock as surface mulch can mimic the desert surface occurring naturally in some areas of Wyoming's intermountain basins. Rock may also deter grazing where protection of seedlings is desired.

5. Erosion control, matting or blankets, are used on slopes steeper than 2.5:1 (run/rise) or areas where maximum soil surface stabilization is desired (i.e., adjacent to water ways). They are available in a large variety of materials depending on project requirements (slope length, gradient, amount of time the blanket will be needed, cost etc.). Erosion may occur beneath blankets if they are not properly installed.
6. Soil binders (stabilizers), tackifiers (alternative names: chemical mulches, bonded fiber matrices, hydromulching) might be used as soil stabilizers. Hydromulching generally is used for steep slopes. Hydromulch is a slurry-like substance made up of mulch and/or synthetic fibers, water and/or other adhesive substances like tackifiers and soil binders, and possibly seeds. Examples of soil binders (stabilizers) for erosion control of include an emulsion categorized as plant based (short and long lived), polymeric emulsion blend, or cementious-based binders that penetrate the soil thus binding the soil particles together.

B. Typical Sediment and Runoff Control Techniques – These techniques are important to prevent soil loss offsite or from soil mixing with other sediment.

1. Sedimentation ponds, specifically for large coal mines are the primary method to prevent sediment from leaving disturbed areas. Sediment ponds, generally designed to hold a 10-year, 24-hour storm event, detain runoff and allow settling of sediment. They should include an outlet to control the outflow rate and an emergency spillway to protect embankments.
2. Sediment traps are temporary excavated basins that are less than 0.5 acre ft. and allow water to pool long enough for sediment to settle. They are installed by excavating below grade or an embankment is built across a swale. Sediment traps should never be installed on a flowing or intermittent stream.
3. Rock check, rock riprap, gabion drop structures dams are used to decrease the velocity of running water in ditches or swales where sediment is deposited in front of them or within these structures. The maximum spacing between dams should be that the toe of the upstream dam is at the same elevation as the crest of the downstream dam.
4. Straw bale barriers and wattles are used in areas of low-velocity runoff. They need to be anchored at the toe of slopes or in ditches where erosion potential is low.
5. Continuous berms (constructed with soil, gravel within geosynthetic fabric or rocks) reduce water velocity, pond water, and allow sediment deposition. They require less maintenance than straw bales and silt fences.
6. Silt fences reduce velocity of running water and trap sediment. They should be used in areas of dispersed low-velocity runoff (not in ditches) and should remain in place until vegetation has been established. They should be installed in association with other erosion control measures and maintained on a regular basis.
7. Channel lining should be designed according to the volume and velocity of the expected flow. These linings include temporary and permanent liners, either with rigid lining (concrete, stone masonry, grouted rock, etc.) or flexible lining (vegetation, erosion control blankets, gravel, rock etc.).