Properties and Land Use Potentials of Surface Mined Landscapes in the Virginia Coalfields

2002/2003 Powell River Project Annual Progress Report

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Introduction

Over the coming decade, the Natural Resources Conservation Service (NRCS) will be actively mapping the coalfield counties of southwest Virginia in cooperation with the Virginia Tech Soil Survey program. Currently, there are very few established mine soil series for field mappers to work with; the vast majority are from West Virginia or Kentucky. Similarly, formal NRCS soil interpretations for various land-uses on mined lands are very limited or actually nonexistent. This project was successfully initiated in 1998/1999 and was cooperative with VDMLR, NRCS, local governments, and other interested agencies and groups. This report summarizes our overall results for the complete research program. Greater detail on all of the research components can be found in previous annual reports, and as indicated later, additional work will be reported in this outlet over time as final mine soil interpretations are developed for regional implementation.

The overall objectives of this research program were as follows:

1. To work cooperatively with existing NRCS National Cooperative Soil Survey parties in the Virginia coalfields to develop and apply viable mine soil mapping concepts.

2. To map in detail and classify the mine soils that occur in the Powell River Project Research and Demonstration Area (Education Center) and the local watersheds.

3. To develop and Geographic Information System (GIS) for the Powell River Project Education Center area and make that GIS available to PRP personnel.

4. To develop and test a set of mine soil interpretations for the mine soil taxonomic units developed in Objective #3 above. These interpretations will be based on the Powell River Project's accumulated knowledge base, and will address (at a minimum) forestry, revegetation/erosion control, hayland/pasture, lawns and gardens, septic suitability, and urban development.

Overall Research Approach and General Methods

This project was completed over a five-year period in cooperation with the various agencies and organizations listed above. Research objectives #1 and #2 were accomplished via active liaison with the current NRCS party leaders (Mr. Dave Wagner, Mr. Tom Adkins, and Mr. Jeff Thomas) in Buchanan, Russell and Scott Counties, respectively. We assisted Mr. Wagner with mapping legend verification, laboratory analysis of mine soil pedons, assistance with field reviews, and consultations on mapping unit composition. Jeff Thomas worked with us on the detailed mapping and correlation of soils at the Powell River Project Education Center area. The field mapping work associated with Objective #2 was accomplished over the summer of 2001 through cooperative efforts with Mr. Jeff Thomas of USDA-NRCS. During the 2001/2002 project year, we described 20 mine soil pits within the Education Center mapping area. These pedons were analyzed in our laboratories over the 2002/2003 project year for detailed chemical and physical properties to allow for final mine soil classification and correlation of the cooperative soil survey. Over this final project year, we also worked with NRCS personnel from Buchanan and Russell Counties to characterize the nature and properties of coal waste materials as related to available soil series criteria.

To accomplish Objective #3, we initially worked closely with VDMLR's ongoing geographic information system (GIS) development efforts, coordinated by Mr. Doug Mullins. For this program component, we decided to focus our activities upon the Powell River Project Education Center area at the head of the Powell and Guest River drainages, and we have used the ArcView^{tm} and ArcGIS systems for this application.

Finally, over the past two project years, working cooperatively with Ms. Jeannine Freyman of the NRCS, we have continued to compile all applicable Powell River Project findings and data sets that are pertinent to the development of accurate mine soil interpretations. To meet objective #4, we have been working with other Powell River Project researchers to develop specific interpretations for land use potentials as affected by variations in mine soil type and associated mined landscape properties.

Overall Program Results and Accomplishments

I. Development of viable Mine Soil Mapping Concepts (Obj. #1), and Mapping Characterization of the Mine Soils in the Powell River Project Area (Obj #2)

Powell River Project Education Center Mine Soil Studies

The results of this research component have been discussed in great detail in past annual reports, and are summarized in the following two abstracts for papers (Haering et al., 2004 a&b) which have been submitted to the *Soil Science Society of America Journal*.

Paper #1 – Mine Soil Properties and Morphology Over Time

Surface coal mining and reclamation methods in the Appalachians have changed dramatically since the passage of the Surface Mining Control and Reclamation Act (SMCRA) of 1977 and subsequent improvements in mining and reclamation technology. In this study, 30 pre-SMCRA mine soil profiles (4-20 yr old) were examined and sampled in 1980 and compared to 20 mine soil profiles (8-13 yr old) described in the same area in 2002 after it had been completely re-mined by modern deep cut methods. Mine soils in both sampling years had high coarse fragment content (42 to 81%), relatively well-developed A horizons, and generally exhibited A-C, or A-AC-C horizonation. Although six Bw horizons were described in 1980, only two met all requirements for cambic horizons. The 1980 mine soils developed in overburden dominated by oxidized, pre-weathered material due to relatively shallow mining cuts. The 1980 mine soils had lower coarse fragment content, finer textures, lower pH, and tended to be more heterogeneous in horizonation, morphology, and texture than soils observed in 2002, which had formed primarily in unweathered overburden from deeper cuts. Half the pedons sampled in both years had densic materials within 70 cm of the surface. Four poorly to very poorly drained soil profiles were described in each sampling year containing distinct hydric soil indicators in surface horizons. While older pre-SMCRA mine soils do have many properties in common with newer mine soils, their properties are highly influenced by the fact that they generally have formed in more weathered overburden from higher in the geologic column. Overall, Appalachian mine soils are much more complex in morphology than commonly assumed, and differential compaction greatly complicates their internal drainage and limits their overall productivity potential.

Paper #2 – Mine Soil Classification and Mapping Issues

Soils formed on lands mined for coal in the Central Appalachians are currently classified by the USDA system of Soil Taxonomy as Typic Udorthents, which does not distinguish these unique anthropogenic soils from naturally formed Udorthents. In this study, we evaluated the effectiveness of currently utilized mine soil series for describing the properties of a range of mine soil pedons in southwest Virginia. Using established series concepts, we mapped and classified approximately 450 ha of mine soils in an area that had been reclaimed in accordance with the U.S. Surface Mining, Control, and Reclamation Act (SMCRA) of 1977. We also used current series concepts to reclassify mine soils in an adjacent and overlapping 250 ha that had been mined prior to SMCRA, and had been mapped in1980 using older mine soil classification criteria in 1980 that was not based on the USDA Soil Taxonomy system. Established mine soils series concepts provided adequate information on particle-size and reaction class, but did not adequately describe rock type or parent materials. More importantly, the established series concepts did not allow for impeded drainage, densic layers, shallow depth classes, and cambic horizons, all of which occurred in this study area, and are important criteria for separating soil series. Using current taxonomic/mapping procedures, soils with these properties would be mapped as undifferentiated, non-limiting, inclusions. Since drainage class, densic layers, and soil depth and degree of development directly affect soil management, we feel that it is important to recognize these features in mine soil classification, either as part of a revision of the present system, or via adoption of a new system of classification for these highly man-influenced soils.

Development of Final Mapping Legend for Education Center Area

As an intrinsic component of the work described above, we have worked with Mr. Jeff Thomas of the NRCS to develop and test a "workable" mine soil mapping legend for the detailed (scale ≤ 1:12,000) mapping of mine soils in the Powell River Project Education Center Area. The proposed mapping units/legend are listed below:

1F	Rocket-Sewell-Rock outcrop complex, 55 to 150 percent slopes, extremely stony
2B	Rocket-Powellriver complex, 2 to 8 percent slopes, extremely stony
3B	Fiveblock very cobbly sandy loam, 2 to 8 percent slopes, extremely stony
3C	Fiveblock very cobbly sandy loam, 8 to 15 percent slopes, extremely stony
4B	Rocket-Sewell complex, 2 to 8 percent slopes, extremely stony
4C (1C)	Rocket-Sewell complex, 8 to 15 percent slopes, extremely stony
4D	Rocket-Sewell complex, 15 to 35 percent slopes, extremely stony
4E (1E)	Rocket-Sewell complex, 35 to 55 percent slopes, extremely stony
4F	Rocket-Sewell complex, 55 to 80 percent slopes, extremely stony
5B	Sewell gravelly loam, 2 to 8 percent slopes, very stony
6E	Gilpin-Shelocta complex, 35 to 55 percent slopes
W	Water (pond)

Notes: Rocket and Powellriver are proposed new series concepts discussed in detail by Haering *et al.* (2004 a&b).

Commentary on use and application issues by Mr. Thomas:

The data from the 19 pits investigated on-site suggest that these mine soil properties are highly variable over short landscape distances. The highly variable properties are rock fragment type, consistence, reaction, and color. Clay content is less variable and is <18% in most (or all) areas. The high degree of variability has been noted in many mine soil landscapes in Virginia, West Virginia, Pennsylvania, Ohio, and others. The high variability may best be recognized by naming map units as complexes or associations, as well as widening the range of characteristics of the mine soil series to the extend as allowed by ***Soil Taxonomy*** and other map unit naming conventions. In the above legend, reaction, particle size, drainage, and rock type weighted heavily in naming of the map units.

The data set from the 19 pits indicates that:

Reaction class varies from nonacid to acid
Fine earth texture is fairly predictable.
Rock type is variable, ranging from mostly gray sandstone, to mostly brown sandstone, to a mixed rock type.
Drainage class is predictable, based on microtopography.

Brief rationale for naming of map units:

Map units 4B, 4C, 4D, 4E, and 4F: These areas contain both acid and nonacid mine soils. Rock type was mostly mixed but significant areas contain mostly sandstone (varying proportions of gray ss vs. brown ss). Rocket and Sewell encompass this range in rock type and acid classes.

Map unit 2B: These areas have a mixed rock type, but pockets of dominantly gray sandstone can occur. Nonacid mine soils appear to be dominant. The Powellriver mine soil is associated with depressed topography, convex shaped areas had the Rocket or Sewell mine soils. This unit could alternately be named Fiveblock-Powellriver complex if there is a need to recognize the dominantly gray sandstone areas. Rocket was used over Fiveblock since the mixed rock type appeared to be dominant. The poorly drained areas, Powellriver, are significant in extend, and need to be named. Most of the pits in these map units were selectively placed in the depressed areas, only a few were placed in the convex shaped areas. Map unit composition, based on aerial photography interpretation and on-site observation, suggest that the unit is about 15 to 25 percent poorly drained Powellriver and similar mine soils, and 75 to 85 percent Rocket and similar (Fiveblock) mine soils. The proportional extent of the Powellriver mine soils may increase in time as soil genesis continues to occur.

Map unit 3B and 3C: Remains as originally proposed using Fiveblock. Areas that are mostly gray sandstone with a nonacid reaction class.

Map unit 1C and 1E: Appear to be the same or similar to 4C and 4E. The original intent was to map the areas where reclamation was limited or had partially occurred, or where the mine soils were relatively young. The concept was that these areas may be more acid that other parts of the project area. This concept partially held up, but nonacid mine soils appear to occur in the large extent.

Map unit 1F was renamed using the same concepts of map unit 4F, but includes Rock outcrop in the map unit name to recognize the exposed highwalls.

Map unit 5B: Historical information suggests that the areas mapped as 5B are older reclaimed areas of the Sewell mine soils.

<u>Need for Additional data:</u>
Saturated hydraulic conductance (K_{sat}) is used by the NASIS interpretative generator. The mine soils that were established in West Virginia have a moderate or moderately rapid permeability, and NASIS does not give a restricted permeability rating for these mine soils. I have reviewed a few series from Ohio, and one from WV, that are moderate or moderately slow. Given the density of the mine soils that the Powell River Project area, I would recommend that a permeability of moderate, moderately slow, or slower be assigned to the Rocket and Powellriver series, possibly moderate to moderately slow. This would generate a restricted permeability interpretation for septic tank absorption fields. Any existing K_{sat} data would be helpful. Dr. John Sencindiver at WVU has done

Ksat studies on mine soils in WV, possibly that would be a source of guidance.

Studies of Mine Soils in Coal Refuse

During the past year, we continued working on current and proposed mine soil series concepts in cooperation with NRCS soil scientists David Wagner and Lori Hillman (Buchanan County), Tom Adkins (Russell County), and Jeff Thomas (Scott County). Much of our work focused on describing and characterizing mine soils formed in coal refuse. The pedon descriptions cited as Pedons 1-4 below are found at the end of this report.

Currently, the only established soil series used to map soils forming on Appalachian coal refuse piles is Itmann, a series established in West Virginia in 1984. Itmann soils are extremely to strongly acid (pH 3.5 – 5.5) and have formed in parent material containing more than 50% carbolithic material (coal, waste coal, or high carbon shales and siltstone). Older refuse piles often meet the criteria for Itmann because they typically contain high percentages of coal that was not separated in the cleaning process. Modern coal cleaning technologies are more efficient, however, and newer refuse piles tend to have much lower percentages of carbolithic materials than older piles. Soils formed on these piles do not meet the > 50% carbolith requirement for Itmann series. Modern refuse piles also tend to be larger than older refuse piles, and can cover up to hundreds of ha. Some of these piles contain coal refuse with a non-acid (pH > 5.5) reaction, a property which affects both reclamation method and revegetation success. Thus, new series are needed for accurate mapping and classification of modern refuse piles.

To this end, NRCS personnel currently mapping in Virginia are proposing two new series for soils formed in modern coal refuse. David Wagner, in Buchanan County, is proposing a new series, Dismal, for modern refuse piles with a pH of <3.5 to approximately 5.5 (Pedon 1). Tom Adkins, in Russell County, is proposing a new series, Stonecoal, for modern refuse piles with a pH of 5.5 to 9.0 (Pedon 2). Although rock fragment type will include coal as well as sandstone, siltstone, and shale, both series will have < 50% carboliths. Both series will be classified, like Itmann, as loamy skeletal, mixed, semiactive, medic, Typic Udorthents. Itmann and Dismal are/will be classified as acid, while Stonecoal will be classified as non-acid. Although the range of characteristics for both Dismal and Stonecoal. Along with Itmann, both the Dismal and Stonecoal series can be either unvegetated (unreclaimed) or revegetated, and can have from 0 to 50 cm of topsoil or topsoil substitute cover. These properties will likely be described as series phases – for example, "unreclaimed", or "reclaimed, non-topsoiled", or "reclaimed, topsoiled". Tom Adkins' typical pedon for Stonecoal (Pedon 2) is an example of an unreclaimed pedon of Stonecoal. This pedon does not have an A horizon because it is barren of vegetation. During the past year, we also described Stonecoal pedons that were reclaimed by direct seeding (for example, Pedon 3), and pedons that had been reclaimed by topsoiling (Pedon 4.)

Technically, refuse piles with soil/overburden covers deeper than 50 cm (20 inches) do not fit into the stated or proposed range of characteristics of these series, and would be mapped as other mine soil series based on the properties of the soil cap. In an earlier mapping legend from Buchanan County, refuse piles with a soil layer > 50 cm at the surface were mapped as a Cedarcreek/Sewell (both acid mine soils) complex. However, the presence of coal refuse at > 50 cm in the profile will strongly affect many land use interpretations, and should be addressed at some level of the mapping and/or classification process.

The only land-use interpretations for a soil series formed in Appalachian coal refuse that are currently available are the interpretations for the Itmann series. As has been mentioned in previous reports, these interpretations were apparently adapted from those for soils of the same classification that were not formed in coal refuse, and thus do not address many of the specific issues presented by coal refuse parent material. Post-reclamation land-use possibilities for coal refuse piles are quite limited, and the land-use interpretations for soils forming on these areas should reflect that.

II. Development of a Powell River Project Education Center Geographic Information System

The Powell River Project GIS was expanded again this year via the addition of several data layers based upon (1) early detailed soil mapping completed by Daniels and Amos (1981), and data on other research plot locations provided by Carl Zipper. The Powell River GIS was upgraded last year from the existing software, ArcView 3.2 to ArcGIS, new software introduced by ESRI, the premier GIS software manufacturer. ArcGIS has many new features that make overlaying, displaying, and analyzing various data layers simpler and allow more flexibility. Until most of the Powell River GIS users upgrade to the new software, the GIS will be maintained in both software programs (ArcView 3.2 and ArcGIS).

III. Examining Existing Mine Soil Interpretations

During the 2001-2002 project year, Jeannine Freyman of NRCS entered the initial draft of mapping legend for the Powell River Project (adapted from the Buchanan County mapping legend) into the NRCS National Soil Information System (NASIS). NASIS is a generic software tool for managing data in a relational database system. We were then able to generate standard interpretation tables for the Fiveblock, Sewell, Kaymine, and Cedarcreek mine soil series from NASIS, which were analyzed and dissected in detail as discussed in last year's report.

Last year's annual progress report presented a detailed summary of the problems and challenges that we have faced collectively with NRCS in our cooperative attempt to update the existing NASIS data base for existing soil series. Work on these two sub-objectives/goals continued over the past year, but was not completed for a variety of reasons. However, as noted later, it is our intention to complete this work over the coming year as an in-kind contribution to the overall project.

Overall Summary and Conclusions

Over the past five years, this research program has developed a considerable body of new knowledge about the properties and behavior of southwest Virginia mine soils. Due to our 20 years of research history in the area, we were also able to relate the properties of current-day mine soils to their mining and reclamation history. We have also been able to develop a model of soil genesis for these materials as they weather and transform over time. A careful review of existing mine soil series and mapping concepts revealed that many mine soils in the Powell River Project Education Center area did not fit any existing soil series, and two new series concepts have been developed, tested, and proposed for future adoption by NRCS. Collectively, our work continues to point out the very important roles that parent material, pre-mining overburden weathering status, and compaction during mine soil construction play in controlling resultant mine soil properties. Compacted (densic) layers are a dominant land-use limiting feature in southwest Virginia mine soils and play an important role in producing wet, poorly-drained soils in post-mining landscapes.

This program has successfully generated an ArcView 3.2 and ArcGIS Geographic Information System for the Powell River Project Education Center Area that will be made available to all researchers and approved users over time. The GIS will be maintained and upgraded by our staff as requested. Finally, it is clear that we need to continue our efforts to correct and improve the existing NASIS soil interpretations for existing mine soils, and then carry over those improvement to any new or existing soil series that are utilized for mine soil mapping in southwest Virginia. We intend to continue and complete this effort over the coming project year as an in-kind contribution to the completion of the originally proposed research program. The regional NRCS office in Lexington KY has also offered a limited amount of support over the fall of 2003 to complete our backlog of laboratory analyses on mine soil pedons sampled in 2003.

Acknowledgments

We would like to thank Jeff Thomas for his soil mapping skills, Danny Early for his for his expertise in backhoe operation and maintenance, and Jon Rockett for his consistent help with many aspects of this project – we could not have completed this year's objectives without the help of these three people. Amanda Burdt, Kelly Smith, Ron Alls, and Steve Nagle all helped considerably in describing and sampling the soil pits. The laboratory assistance of W.T. Price, Christina Capuano, and Megan Carter is also gratefully acknowledged.

In addition to the direct support of the Powell River Project, we have received significant in-kind support from the NRCS. We are particularly grateful for the assistance of Jeff Thomas, Jeannine Freyman, David Wagner, Tom Adkins, Lori Hillman, and Glen Graham in this cooperative effort.

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Selected Mine Soil Pedons formed in Coal Refuse Materials

Pedon 1. Draft typical pedon description for proposed Dismal series (modified from original written by David Wagner, USDA-NRCS, Buchanan County). This pedon had been covered with a layer of topsoil substitute (A and AC horizons), and planted with grass and trees.

A 0-5 cm. Dark yellowish brown (10YR 4/4) gravelly silt loam with common fine faint lithochromic brown (10YR 5/3) mottles; weak very fine and fine granular structure; friable, slightly sticky, nonplastic; many very fine and fine roots; many very fine irregular and tubular pores; 20 percent sandstone fragments (60 percent gravel, 10 percent cobblestones to 6 inches, 30 percent channers to 6 inches, 10 percent flagstones to 10 inches); very strongly acid; abrupt wavy boundary.

AC 5-64 cm. Dark yellowish brown (10YR 4/4) gravelly silt loam with common fine faint lithochromic brown (10YR 5/3) mottles; weak fine and medium granular structure; friable, slightly sticky, nonplastic; many very fine and fine roots; many very fine irregular and tubular pores; 20 percent sandstone fragments (60 percent gravel, 20 percent cobblestones to 6 inches, 10 percent channers to 6 inches, 10 percent flagstones to 10 inches); very strongly acid; abrupt wavy boundary.

2C1 64-76 cm. Very dark gray (10YR 3/1) extremely channery sandy loam with common medium and coarse prominent lithochromic strong brown (7.5YR 4/6) and yellowish brown (10YR 5/6) coatings on rock fragments; massive; very friable, nonsticky, nonplastic; common fine and very fine roots; many very fine irregular and tubular pores; 70 percent fragments (70 percent channers, 80 percent to 3 inches, 20 percent 3 to 6 inches, 30 percent gravel; 90 percent sandstone, 10 percent mudstone); extremely acid; gradual wavy boundary.

2C2 76-162 cm. Very dark gray (10YR 3/1) extremely channery sandy loam with common medium and coarse prominent lithochromic strong brown (7.5YR 4/6) and yellowish brown (10YR 5/6) coatings on rock fragments; single grain; loose; many very fine irregular and tubular pores; 75 percent fragments (70 percent channers, 50 percent to 3 inches, 50 percent 3 to 6 inches; 30 percent gravel, 90 percent sandstone, 10 percent mudstone); extremely acid.

Notes: This pedon was located in a refuse area in Harper Creek, above VA-638, about 2.6 miles east of town of Grundy, 2.5 miles southeast of VA-83, 1 mile north northwest of Dismal Creek, Latitude 37d. 15' 16", Longitude 82d. 02' 18", Grundy, Virginia Quadrangle. Pedon designation was S02VA-027-193 (1-2).

Pedon 2. Draft typical pedon description for proposed Stonecoal series (slightly modified from original written by Tom Adkins, USDA-NRCS, Russell County). This pedon is unreclaimed (not topsoiled and/or revegetated.)

C1 0-79 cm. Black (10YR 2/1) extremely channery sandy loam; massive; firm; 65 percent channers and 15 percent gravels (49 percent sandstone, 48 percent shale, 3 percent carbolith); slightly alkaline; gradual wavy boundary.

C2 79-99 cm. Black (10YR 2/1) extremely channery sandy loam; massive; firm; 75 percent channers and 5 percent gravels (50 percent sandstone, 47 percent shale, 3 percent carbolith); moderately alkaline; clear wavy boundary.

C3 99-172 cm. Black (10YR 2/1) extremely channery loamy sand; massive; firm; 80 percent channers (50 percent sandstone, 48 percent shale, 2 percent carbolith); moderately alkaline.

Notes: This pedon was located on a southeast facing slope in a barren area at an elevation of 1900 feet in Russell County, Virginia; Castlewood District; 1.2 miles north-northeast of intersection of VA 615 and VA 616. U.S.G.S. Carbo topographic quadrangle; latitude 36 degrees, 57 minutes, 30 seconds N and longitude 82 degrees, 11 minutes, 35 seconds W; NAD 27.

Pedon 3. Description of a Stonecoal pedon that has not been topsoiled, but has been revegetated by direct seeding of grasses and legumes.

A 0-8 cm. Black (10YR 2/1) very channery sandy loam; weak fine granular and weak fine subangular blocky structure; friable; 45% coarse fragments (channers and gravels: 78% shale, 20% siltstone, 2% coal); many fine and very fine roots; neutral (pH 7.02); clear wavy boundary.

C1 8-73 cm. Black (10YR 2/1) extremely channery sandy loam; massive; firm in place; 65% coarse fragments (channers and gravels: 80% shale, 23% siltstone, 2% coal); few very fine roots; neutral (pH 7.24); clear wavy boundary.

C2 73-120+ cm. Black (10YR 2/1) extremely channery sandy loam; massive; very firm in place (possibly densic); 65% coarse fragments (mostly channers and gravels with some stones: 50% shale, 45% siltstone, 5% coal); no roots; slightly alkaline (pH 7.68).

Notes: This pedon was located on the Moss #3 refuse pile near Carbo, in Russell County Virginia, and was approximately 2 years old. The pedon had not been topsoiled. Vegetation consisted of an adequate (approximately 80% cover) stand of tall fescue, and clover. Slope was

5%; aspect was 300 degrees; latitude and longitude were 36d57'24"N; 82d11'45"W. Described by Tom Adkins, Dave Wagner, Kathryn Haering, Lori Hillman, and W. Lee Daniels on 4/15/03. Pedon designation was S03-VA-167-7.

Pedon 4. Description of a Stonecoal pedon that has had a layer of topsoil applied (the A horizon), and has been revegetated with grasses and legumes.

A 0-36 cm. Olive brown (2.5 Y 4/4) very channery loam, with 2-3 cm dark brown (10 YR 3/3) layer at surface; weak medium subangular blocky structure with some weak fine granular structure at top of horizon; friable; 45% coarse fragments (channers, with some flagstones and stones: 65% shale; 20% siltstone; 15% sandstone); many fine and very fine and common medium roots; neutral (pH 7.01); clear wavy boundary.

2Cd 36-150+ cm. Black (10YR 2/1) extremely channery sandy loam; massive; very firm in place; 65% coarse fragments (mostly channers with some flagstones: 80% shale, 15% siltstone, 5% coal); few fine and very fine roots in top 25 cm of horizon; slightly alkaline (pH 7.70).

Notes: This pedon was located on the side of a lower terrace of the Moss #3 refuse pile near Carbo in Russell County, Virginia, and was approximately 20 years old. The pedon consisted of a topsoil cap (the A horizon) over compacted coal refuse (2Cd). Water was perched between the A and the 2Cd horizons, and was seeping into the bottom of the pit. Vegetation was a closed stand of tall fescue and clover. Slope was 30%; aspect was 160 degrees; latitude and longitude were 36d59'16"N; 82d10'58"W. Pedon designation was S03-167-4.