SOIL AND OVERBURDEN MANAGEMENT IN WESTERN SURFACE COAL MINE RECLAMATION - FINDINGS OF A STUDY CONDUCTED FOR THE CONGRESS OF THE UNITED STATES - OFFICE OF TECHNOLOGY ASSESSMENT [1]

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This study describes soil and overburden management under the permanent regulatory program and was conducted to assist OTA in their assessment of environmental protection of federal coal lands. There are uncertainties in baseline data collection, soil and overburden handling, models of reclamation success and bond release. Innovation, regulatory control, reclaimability, and bond release are important issues discussed in this study.[3]

INTRODUCTION

In May of 1984, Morris Udall, chairman of the House Committee on Interior and Insular Affairs asked the Office of Technology Assessment (OTA) to conduct an assessment of western surface coal mining. Mr. Udall asked: are there physical or technical limitations...to reclaiming...federal mined lands in the western U.S.? What is the state of development of technologies and methodologies...and what is the status of monitoring reclamation...and how are the monitoring data being used? Are the regulatory policies and practices...effective in administrating federal surface mining legislation? This study was conducted to assist OTA in answering some of these questions (OTA 1984).

The study describes soil and overburden management in reclamation of western surface coal mines. The study is based on a review of the literature, permit applications, state and federal acts, regulations and state guidelines, as well as interviews with the regulatory authorities, environmental managers, staff scientists, researchers, and environmentalists.

Purpose

The purposes of this study are to: describe the data and analytical techniques used in the baseline chacterization of soil and overburden resources; evaluate the use of that information in reclamation planning; describe the methods used by the regulatory authorities in evaluating reclamation plans; determine if the baseline data accurately predict the conditions found during mining; describe reclamation monitoring and the criteria for reclamation success; evaluate the effectiveness of the regulatory programs; and suggest alternatives for resolving uncertainties and improving the process.

Scope

This study addresses soil and overburden management at western surface coal mines. As used in this study, soil refers to the unconsolidated material from the surface to the first stratum of weathered bedrock and the term overburden excludes the soil. Overburden is used generically to refer to strata overlying or between coal seams unless it is used with the term interburden, in which case overburden refers to the strata above the highest coal and interburden refers to the strata between coal seams to be mined. Topsoil refers to the surface layers of a natural soil or any materials used as a soil topdressing over recontoured spoil, a useage consistent with the terminology of the law.

The study area comprises North Dakota, Montana, Wyoming, Colorado, and New Mexico. Most of the mines involve federal land and all were permitted under approved state permanent regulatory programs, as per the Surface Mining Control and Reclamaton Act, Public Law 95-87, referred to here as SMCRA.

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Thirteen case study mines were selected to be representative of the great ecologic, geologic, and pedologic differences between mines in the study area. Every mine (but one) has unique soil and overburden problems, that are being solved on a site specific basis. The one exception is a mine chosen to be representative of a benign soil and overburden condition, a situation difficult to find.

Case Studies

The case studies were selected based on recommendations of the state regulatory authorities and environmental groups, and the literature review. The case study analysis began with a thorough review of the permit applications on file at the Office of Surface Mining (OSM) in Denver, or the state agencies. The soil and overburden baseline studies, reclamation plans, state decision documents, and annual reports (if any) were reviewed. The staff soil scientists or environmental coordinators for the mines were interviewed, most by telephone, and a few in person. Two mine site visits also were conducted. The OSM and state regulatory agencies were visited and the soil scientists and/or administrators responsible for permitting were interviewed regarding the state and federal programs and the specific case study mines. The case studies are not identified, to emphasize that the purpose of this report is not to assess the adequacy or inadequacy of the reclamation at any particular mine, but to illustrate the process under the current regulatory and scientific framework.

Analysis

The analysis of the uncertainties in the soil and overburden management process is based on the literature, case studies and interviews. Where there are conflicting opinions on these subjects they are presented where possible. This section is somewhat subjective and the author's opinion is presented (and represented as such).

Issues

The assessment of issues is based on the literature review, review of state and federal acts, rules and regulations, guidelines, permit applications, and interviews with researchers, regulatory authority and industry staff. This section is the most subjective of the report.

SUMMARY OF FINDINGS

Soil and Overburden Management

Baseline Data Collection and Analytical Techniques

Databases.--SCS soil surveys are used as the basis for more detailed site-specific soil inventories. They are of uniform quality and readily available. Because the regulatory authorities require more detailed site-specific soil information, it is not necessary to obtain soil data from adjacent mines even though it would be useful.

Essentially no use is made of overburden data from sources other than onsite drilling. The use of data from nearby mines is unlikely because there are problems with the quality of baseline overburden data in existing permits.

An overburden geochemical database might be developed and used to extrapolate geochemistry from existing mines to new mining areas. The author suggests that overburden samples should be classified according to a uniform lithologic stystem (Ferm et al. 1985) to facilitate the establishment of an overburden database; this might improve our understanding of the geochemical, lithological, stratigraphic and depositional relationships of the coal basins.

Soil Inventory and Evaluation.--Soil baseline studies are in good shape compared to overburden baseline studies. Soils are mapped using the methods of the National Cooperative Soil Surveys which has provided a high level of quality in the soil studies compared to overburden studies.

Laboratory methods for topsoil analyses are fairly reliable agricultural soil tests. The criteria used to determine the suitability of a soil for use in reclamation are critized by industry as being agriculturally biased (not applicable to range plants,) arbitrary and simplistic, but they are probably better than the criteria used to evaluate overburden suitability.

The pre-mine site-specific soil inventories delineate suitable and unsuitable soils with sufficient accuracy to plan soil handling for reclamation planning and permitting. However, the pre-mining inventories are not sufficiently accurate to predict topsoil volume in a one year salvage area or for actual salvage, and intensive staking and (in some cases) sampling is necessary prior to soil salvage.

Soil salvage depths for the same series can vary significantly among mines for a number of reasons. There are chemical and physical differences within a given series, equipment limitations to salvage and variations in test results for the same material. Operators stripping the minimum amount may be concerned with soil quality and operators stripping the maximum amount may be concerned with quantity. In the author's opinion, the differences in soil salvage depths for the same series among mines suggest there are uncertainties in the characterization and handling of the soil resources that have not yet been adequately resolved.

Overburden Drilling, Description and Sampling.--The programs for overburden characterization are full of uncertainties. One

study on the intensity of drill hole spacing necessary to characterize overburden found that an inordinately high intensity of drilling was required to predict accurately the occurrence of deleterious strata (Dollhopf et al. 1981). Most initial drilling programs cannot detect all occurrences or delineate the total extent of deleterious strata, but will indicate those parameters most likely to be of concern. Some available data also suggest that the accuracy of delineating unsuitable overburden zones is not much better with high intensity drilling than with lower intensity.

Lithologic descriptions in most of the permit applications reviewed are minimal. A standardized system for lithologic description would improve overburden characterizations (Ferm et al. 1985).

In most of the cases reviewed for this study, overburden stratigraphy is not very well presented in the permit applications. In much of the coal fields of the study area the strata are lenticular, fluvial deposits that are difficult to correlate. This lenticularity may make detailed stratigraphic analysis impractical and unnecessary. However, there are certain strata that may be correlative over significant distances and certain chemical parameters that may be related to particular strata. In the author's opinion, more research needs to be done on the correlative strata and the related chemical parameters.

Acid, Alkaline and Toxic-Forming Overburden.--The determination of acid, alkaline and toxic-forming strata is a subject of considerable debate in the industry. There are major uncertainties involving the analytical methods used and the criteria on which suitability is based.

The acid potential of the overburden and its affects on revegetation are currently judged from the measurement of acid-base potential (Smith 1974). Acid potential is reported when the acid produced by the oxidation of sulfide minerals (principally pyrites) is greater than the neutralization potential of carbonates (principally lime). Available test methods undoubtedly do not measure the reaction as it would occur on the ground. The acid-base potential analytical method may overestimate the contribution to acidity from organic sulfurs, may not accurately reflect the stoiciometry of the oxidation of the pyrite in the presence of oxidizing bacteria (Dollhopf and Russell 1984) and may not account for the reactivity of the lime (Boon, Smith and Lawton undated). More work must be done on developing methods of determining the acid potential for western overburden.

Acid production from spoil underlying redressed soil could probably adversely affect western reclamation. For many years, acid formation was not considered to be a problem at western coal mines due to ubiquitous lime, but now there are mines with some acid problems.

The regulatory methods for dealing with this issue are different in each state. Wyoming DEQ now considers black carbonaceous shales and some pyritic sandstones to be potential acid-formers that may have to be specially handled and requires acid-base potential measurement on all overburden samples (WDEQ 1984). The North Dakota regulatory authority considers the possibility for acid formation to be extremely limited in that state, and they do not routinely require a measurement of acid potential. The New Mexico regulatory authorities recommend an acid-base potential measurement only on non-calcareous strata (MMD 1984). The Montana regulatory authority may require an acid-base potential measurement depending on the nature of the overburden. Colorado guidelines specify a determination of pyritic and sulfate sulfur for overburden samples (MLRD 1982).

However, some reclamation specialists in industry doubt that acid formation is a potential problem. Eastern Powder River Basin mines in Wyoming are running acid-base potential on all overburden and regraded spoil samples, and special handling known acid-formers and black carbonaceous shales. In the same coal measures in Montana, acid-base potential is not typically run and is not an issue.

There has been some concern that sodium from underlying spoil would migrate into overlying soil and adversely affect the physical properties of the reconstructed soil. Some recent data (Dollhopf 1983, Miyamoto 1983) has been presented by industry to suggest that given certain soil or climatic conditions, sodium migration should not be a problem, but this is not necessarily accepted by the regulatory authority. Montana for example, still requires 8 feet of cover over sodic and clayey spoil.

Toxic overburden in the form of elevated trace metal contents is an issue at three of the case study mines. The placement of overburden in the root zone which might affect plant quality (molybdenum, selenium) or revegetation success (boron) is a potential revegetation problem, but the regulatory programs for predicting whether trace metals in the spoil will be a problem may not be adequate. Monitoring plant quality on the reclaimed surface may be more effective than baseline studies of overburden trace metal content (Neuman and Munshower 1983).

Reclamation Techniques

Soil Handling.--Topsoiling ought to be an optimization process - too little soil and revegetation will be unsatisfactory; too much soil and lots of money is wasted, but topsoil handling is not optimized under the current regulatory framework. The states in the study area (with the exception of Colorado) have adopted the position that all suitable soil will be salvaged, in many cases down to depths of 60 inches or more, without regard to overburden chemical or physical parameters. In most cases

soil is a better root zone material than spoil. Salvage of all suitable soil may be appropriate in many situations, but it is not appropriate in every case. Because the present baseline studies do not predict the characteristics (such as moisture holding capacity) of either the reclaimed soils or recontoured spoils, the justification for salvaging all suitable soil is not present. The available research clearly shows that where spoil can function as a root zone, very little topsoil is required for optimum revegetation success (Barth and Martin 1982, Jensen, Dancer and Duncan 1981, Bauer et al. 1978).

North Dakota and Montana require topsoil salvage and redressing in two lifts. The organic rich first lift material should have better tilth and be biologically active with microbes, seeds, and rhizomes. Having topsoil at the surface of the reconstructed soil should achieve a stable and diverse soil-vegetation system more rapidly than one lift handling which mixes topsoil and subsoil.

Soil to be used as a plant growth media is best preserved if it is directhauled, transferred directly from its native site to a recontoured subsoil or overburden without stockpiling (Hargis and Redente 1984). Direct-haul topsoiling may provide for better rangeland plant diversity than stockpiled soil. Existing regulations discourage direct-haul. For example, the requirement for approximate uniform thickness restricts direct-haul because directhaul does not have the flexibility inherent in the stockpiling system. The requirement for saving all suitable soil, without a requirement for two lifts, makes the direct-haul method less effective; the biologic component of the surface layers that produces the beneficial effects of direct-haul is compromised by the requirement to salvage A, E, B, and C horizons.

For the re-establishment of rangeland, two lift direct-haul might be the best method of topsoil handling. A number of case study mines are using this system with good results. In one of the harshest sites of the five state region, the regulatory authority reports very encouraging revegetation results at a mine using the two lift direct-haul method.

The requirement for approximate uniform topsoil thickness is counterproductive in many ways. It directly conflicts with the requirement to establish a diverse plant community. In fact, uniform topsoil thickness is being interpreted in many cases to allow for non-uniform redressed thickness; several case studies had non-uniform thickness. In the author's opinion, this is an example of considerable regulatory flexibility in the face of an often counterpoductive regulation.

Soil volume accounting is a method that can be used to keep track of soil volumes that have been salvaged and are available for redressing. Environmental groups have criticized the enforcement of adequate soil salvage. Soil volume accounting is a reasonable requirement for mines where soil volumes are marginal and at some mines during the final years of mining where shortages of soil could be critical. However, there is no consensus that it would not be a necessary requirement at all mines.

Overburden Handling.--Special handling, recontoured spoil sampling, 4 feet of cover, burial or treatment are sometimes required where deleterious strata occur in the overburden or spoil. There are uncertainties involved at each step of the process.

Truck and shovel operations in Wyoming are more likely to be required to special handle material than dragline operations because the flexibility of their equipment makes it easier to do so.

Recontoured spoil sampling programs are the norm in Montana and Wyoming, but not in the other three states in the study area. The statistical validity of the recontoured spoil sampling programs has not been established. Statistical analysis of the sampling densities necessary to characterize the regraded spoil for the specific parameters of concern should be conducted at all mines with recontoured spoil sampling programs (Naftz 1984) and the programs modified accordingly or discontinued. The existing programs may be giving a false sense of confidence that deleterious materials on the recontoured surface will be detected.

The requirement for 4 feet of cover over deleterious materials is a subject of debate. Federal regulations originally specified 4 feet of suitable cover over toxic spoil but this has recently been revised to "adequately covered." Wyoming still requires 4 feet, and Montana requires 8 feet; North Dakota requires up to 5 feet (a minimum of 4 feet) of cover over all spoil whether it is deleterious or not. In one New Mexico case study 18 inches of cover over sodic and clayey spoil was permitted because it was all the suitable topdressing material available.

Land Use and Topography.--Federal regulations require that disturbed areas be restored to conditions capable of supporting the uses they were capable of supporting before mining. However, the analysis of land capability and use in the permitting process was fairly cursory in the cases reviewed. A more rigorous treatment of land capability than is presently being used in baseline studies may assure that land potentials are being protected. The USDA Land Capability Classification (Dansdill and King 1978) is an example of a system that could be used to evaluate pre-mine and post-mine land capability.

The requirement to achieve the approximate original contour may be inappropriate for the reconstructed landscape. The post-mining topography should be consistent with the hydrologic characteristics of the reconstructed

soils, the revegetation communities, the reconstructed drainage systems, and the proposed post-mining land use, and should be compatible with the geomorphology of the contiguous areas to the extent possible. The analysis and design of reclaimed topography in the permits reviewed ranged from very thorough to non-existent. Researchers have suggested that the requirement to re-establish the approximate original contour is counter-productive to the best reclamation in North Dakota (personal communication, Doll 1985), but environmentalists consider the requirement for approximate original contour to be an important environmental protection in the law.

Models for Predicting Reclamation Success

When a permit application is submitted with baseline data, a mine plan and a reclamation plan, the regulatory authority must make a finding of reclaimability. This is the most comprehensive and difficult aspect of the entire regulatory program. Some workers have suggested (several persons interviewed disagree) that these findings ought to be supported to some degree by quantitative predictive models, but the findings are presently based on informal qualitative models. In actual practice the regulatory authority evaluates compliance, the spoil quality and soil thickness, the revegetation plan and revegetation success at similar mines.

Some workers suggest that the formalization and development of predictive models ought to be a research objective for the regulatory authorities (Fisher and Judy 1984), but others in industry and the regulatory authority do not agree. There are uncertainties in the reclamation of western coal lands that relate to overburden chemistry and interactions with the soil cover. In the author's opinion, if the uncertainties are to be resolved in the future, better quantitative models need to be developed to predict reclamation success and the models can be refined over time as more data become available. The models will depend on high quality baseline characterization of the soils and overburden, better criteria for the evaluation of topsoil/spoil reconstruction and better monitoring data. It is the opinion of other workers however, that quantitative models would not be better than the current system for predicting reclamation success. The regulatory authorities do not believe that anything in SMCRA authorizes the kind of monitoring that would be necessary to verify the models.

valuation of Reclamation Success and Bond Release

Reconstructed Soils.--The criteria for valuating success of the reconstruction of soils, or bond release or any other purpose, are imited. In most cases, soil reconstruction is onsidered to be a success if it is as thick as redicted in the baseline studies, the lifts (if equired) are in the correct order and erosion es not exceed pre-mine levels. If the permit s any special stipulations regarding soils, these are also evaluated. In most stipulations for soil monitoring there are no criteria for evaluating the parameter being monitored, what would be done should a problem occur or how it might affect the viability of a reclamation plan.

Only two case study mines have quantitative measurements of erosion from reclaimed surfaces on a routine basis. There are no state guidelines for evaluating erosion of reclaimed surfaces for the purpose of bond release.

Recontoured Overburden.--The adequacy of overburden handling and reconstruction of the root zone are evaluated based on the post-mining topography map and regraded spoil sampling program. Industry personnel suggest that the post-mining topography map should be considered an affirmative demonstration that spoil volumes are adequate and not a depiction of exactly what a given area will become a number of years in the future (Montana Coal Council 1984). The regraded spoil sampling programs are intended to determine if the chemical quality of the recontoured spoil is suitable, but there are important uncertainties involved in sampling, analyzing and interpretating the data and there are other criteria (that should be evaluated but are not) such as whether the spoil is functioning as a root zone where intended.

Soil and Spoil Monitoring

Reclaimed soil and recontoured spoils are not being monitored on a routine, long-term quantitative basis on typical reclaimed landscapes; revegetation success is being used as the indicator of the soil/spoil reconstruction success. According to some researchers (Hargis and Redente 1984): "Before we can say that we understand the effects of reclamation treatments we need to monitor revegetation response long enough (5 to 10 years) to see how well the system sustains vegetation production. As a basis for this we need to monitor specific nutrient cycling parameters such as mineralization and immobilization to determine how well the system functions."

Several individuals expressed the opinion that monitoring may be an important research objective but is not supported by the language of SMCRA, and that revegetation success will be an adequate indicator of the success of soil/spoil reconstruction. There are other workers of the opinion that the parameters to be measured to determine revegetation success may not be sufficient to judge the success of soil/spoil reconstruction for the establishment of a permanent vegetative cover. Several researchers and organizations have indicated a need for soil and spoil monitoring (Doll, Merrill and Halvorsen 1984, RRAC and NDPSC 1984, Hargis and Redente 1984, National Research Council 1981).

Issues

Innovation, Ecologic Variability and Regulatory Flexibility

The Need for Innovation.--The need for innovation is an important issue. Reclamation in the west is a new science and it is critical that it be allowed to improve. Whether or not there is sufficient flexibility under the existing regulatory framework is a matter of perspective. Many industry scientists believe there is not; environmentalists and regulators contend there is.

There is a continuing debate between industry on one side and the regulatory authority and environmentalists on the other, on the need for design standards versus performance standards and their affect on innovation. Every operator interviewed expressed a preference for performance standards rather than design standards. From their perspective the movement away from design standards as the result of recent judicial decisions is a welcome trend. They regard performance standards as the most economic and effective approach to assure successful reclamation. However, in the author's opinion, there is some doubt that performance standards can be enforced because there are so few criteria for evaluating soil/spoil reconstruction and very little monitoring of reconstructed soil/spoil profiles.

OSM was repeatedly critized by industry (and by a few state regulatory agency personnel) for being too inflexible (although this study did identify several cases of flexibility on the part of OSM). Naturally, the states argued for more state control. OSM may be trying to regulate the guidelines on a uniform basis so that they avoid allowing a practice in one place and disallowing it in another. This kind of regulation could be detrimental to innovation.

The use of guidelines as opposed to rules may affect regulatory flexibility. Some states are reluctant to have guidelines because guidelines may be interpreted too rigidly. Some state guidelines have been undergoing revisions for years. This creates problems for the industry, but does have the advantage of providing for evolution essential to the growth of the science of reclamation.

Operator Attitude and Regulatory Control

Operators vary in their approach to the regulatory process and, according to the regulatory authority, this will affect reclamation results on the ground. Most companies (in the operations reviewed) have a corporate policy of cooperation with the regulatory authority. A few companies have apparently taken a adversarial position with regard to the regulatory authority. Many of the staff from cooperative operators felt that their companies ended up doing more than the less cooperative companies. In effect the regulatory authority may be imposing stricter requirements on the cooperative operators and less strict on the recalcitrant. One staff member stated that his company was reconsidering it's policy of cooperation.

A possible resolution to the issue of encouraging innovation and maintaining regulatory control is to leave the design standards in the regulations, but make maximum use of the phrase "unless otherwise approved by the regulatory authority." Design standards could be strictly enforced where necessary and the innovative, environmentally concerned operators could be allowed to innovate.

Several individuals expressed the opinion that there needs to be better direction from the regulatory authority concerning the major problems to be addressed. The task for the regulatory agencies will be to provide this direction without stifling innovation and without ignoring ecologic variability.

Findings of Reclaimabilty

Problems in the Affirmative Demonstration of Reclamation.--SMCRA requires that the application affirmatively demonstrates that reclamation can be accomplished. There are uncertainties in the baseline analyses, reclamation techniques, models of reclamation success and the criteria by which to judge reclamation success. One of the purposes of SMCRA is to assure that the coal supply essential to the nation's energy requirements and to its economic and social well-being is provided. As a result, a few mines are being permitted that have potential problems of indeterminate magnitude, a situation which is probably unavoidable at this time given the state of the art.

Land use is central to the concept of reclaimability. Unfortunately, the baseline characterization of pre-mining and post-mining land use is the most inexact characterization in the baseline studies. In the author's opinion, a more rigorous approach is needed to characterize pre-mining land uses and predict the capability and productivity of the reclaimed lands, in order to document the findings of reclaimability and demonstrate that the findings have been made objectively.

Permit Approval and Reclaimability.--Several permits reviewed contained stipulations to monitor the chemistry of reconstructed soils based on the presence of deleterious chemical parameters in the overburden. These stipulations ought to include clear statements as to how the parameters will be interpreted, what will be done if a problem develops and how such a problem might affect the viability of the reclamation plan.

The findings of reclaimability may be the most difficult and comprehensive aspect of the regulatory program. This report documents a number of technical uncertainities that affect

these findings. For example, there are uncertainties in baseline characterizations, uncertainties in overburden and spoil handling, and differences of opinion as to the adequacy of predicting and judging reclamation success. There are also regulatory considerations that may have affected the findings of reclaimability. Few, if any, permits have been denied (although some people argue that there is no such thing as an unreclaimable site and others that a permit will not get to the permitting stage if it is likely to be denied). There is also the possibility that mines were permitted in order to bring them under the permanent regulatory program. A few mines have stipulations for monitoring a soil problem without a determination as to how it might affect reclaimability. Finally, there is the opinion (of at least two staff members of the regulatory authority) that it would be unrealistic to deny a permit to some existing operations on the theoretical basis of uncertain reclaimability.

In most of the thirteen case studies reviewed, there is no reason to doubt that reclamation will be succeasful. However, there are several mines that have problems that might affect portions of the reclaimed surfaces and may require unusual measures to achieve reclamation success, and there are differences of opinion about reclaimability at two or possibly three of the case studies reviewed. In one case, the post-mining land use objective may or may not adequately reflect pre-mine capabilities. At another, the magnitude of the acid overburden problem is not clear and the availability of sufficient cover is uncertain. At yet another, the effect of a parameter being monitored on reclaimability is not clear. Two of these cases were operating mines when permitted under the permanant regulatory program. Some workers believe that there is no such thing as an un-reclaimable site, but in the author's opinion, it is uncertain whether negative decisions of reclaimability could be made given the state of the art and the current regulatory framework.

Reclamation Success, Soil Monitoring and Bond Release

There are only minimal criteria for evaluating the reconstructed soils on reclaimed landscapes. Soil reconstruction success is presently determined by soil thickness, an inadequate measure. A soil productivity index should be developed to relate potential production to field, chemical, physical and mineralogical properties and to landscape position (Doll, Merrill and Halvorsen 1984). This index could be used to judge the success of the reconstructed soil. The SCS land capability classification system, which considers numerous soil, landscape and climatic parameters, is an example of another index that could be modified to evaluate the success of soil reconstruction.

Monitoring is not being conducted on a routine, long-term basis (10 years) on typical reconstructed soils. In the absence of soil monitoring data, the only available measure of the soil condition will be the revegetation monitoring. For the purposes of bond release, no state has approved guidelines for evaluating success of the reconstructed soil. The regulatory authorities suggest that the success of revegetation will be a sufficient measure of soil and spoil reconstruction, but once the spoil is sampled according to the regraded spoil sampling program (if any) and covered with soil, it will not be evaluated again unless it contributes to vegetation failures.

In the author's opinion, the lack of criteria to evaluate the success of reconstructed soils, the lack of monitoring data on reconstructed soil/spoil landscapes and the lack of specific bond release criteria for reconstructed soils, is a problem for two reasons. There may be cases where vegetation response in years eight through ten of the bond release period will not adequately reflect the soil conditions and will not assure a permenent vegetation cover. In addition, there is a very significant difference in the quality of baseline data, analytical methods and reclamation planning submitted in the permits and approved by the agencies. If this difference persists through the bond release process there will be differences in the quality of the reconstructed soils on post-mining landscapes, that will be more a reflection of operator attitude than avaliable pre-mining resources.

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