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**Suggested Guidelines for Method of Operation
in Surface Mining of Areas with Potentially
Acid-Producing Materials**

Developed by Surface Mine Drainage Task Force

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I. INTRODUCTION

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On September 15, 1978, a meeting was held at the West Virginia Department of Natural Resources Operations Center in Elkins, West Virginia. The meeting was called by D.N.R. Director David Callaghan, for the purpose of addressing the problem of acid mine drainage associated with surface mining of the Kittanning coal seams in the Buckhannon, Tygart and Middle Fork River watersheds. At a subsequent meeting, an interdisciplinary committee was appointed by Director Callaghan. The committee was made up of industry and D.N.R. representatives, as well as technical experts from West Virginia University, the consulting field, and from the Federal Office of Surface Mining. It was charged with the task of defining the problem at hand and of outlining procedures currently available which will provide for recovery of mineral resources while maintaining proper quality of the waters of the state, both during and after operation.

The initial findings of the committee indicated that the acid water problem is site specific. Some mining operations and regions exist within the subject watersheds which do not produce acidic water, due to the nature of overburden present and other factors. Also, some existing operations on sites that may otherwise have produced acid water have minimized the problem by utilizing appropriate mining and reclamation methods.

Companies with interests in the area should realize that the potential does exist for many of their operations to produce acid water. The primary environmental objective should be prevention of acid water, both as a matter of economics and of environmental protection. Although acid water can be successfully treated, it is recognized that creating the necessity of treatment for an indefinite term after reclamation, or even perpetual treatment, is not a desirable situation.

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Statement of purpose: The intent of this document is to present for consideration procedures which the committee believes will be successful in preventing acid water problems on surface mine sites. The information set forth reflects knowledge available to the committee of the current state of the art. Additional research in some areas and field trials of various procedures are needed and should be encouraged.

All companies continuing or planning operations in the identified problem area, or areas with similar characteristics, must realize that successful mining under these circumstances will in all likelihood require special procedures for material handling, and other measures to prevent acid water problems. The methodologies outlined herein are available to be used as guidelines. They are not to be applied as new regulations, supplements to existing regulations, or permit requirements.

This committee recognizes that problems vary from site to site and should be approached with this in mind. The committee also notes that other methods for mining and reclamation may be presently known or will be developed in the future which will prove successful in preventing acid water problems. In no event should this document be applied to the extent of precluding application of prudent mining practices and sound judgement.

II. BASIC CONSIDERATIONS

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In determining a method of operation for surface mining in areas with potentially toxic* materials, several basic characteristics of the mine site should be taken into account:

- A. **Groundwater Characteristics** are important in determining appropriate mining and reclamation procedures and in choosing locations and techniques for valley, head-of-hollow, or other off-bench fills. Data on ground water quality, quantity, and location should be accumulated prior to mining, from springs, seeps, and/or wells in the vicinity.
- B. **Surface Water Characteristics:** As with groundwater, careful study of premining surface water characteristics, including quantity and quality, should play a part in mine planning. Collection and retention of such data on surface and groundwater before, during, and after mining, will be a basis for final bond release, as regulations are currently proposed. Location and nature of streams, whether ephemeral, intermittent, or perennial, should be accounted for in planning sequence of mining and fill configuration and placement techniques. If large watersheds exist above the area to be mined, and/or intermittent or perennial streams are present, handling measures such as buffer zones, diversion channels, and other conveyances for surface flows around or through disturbed areas may be considered. Small watershed areas and existence of no streams other than those identified as ephemeral may indicate little or no special surface water handling provisions.

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*The word toxic, as used throughout this document, is synonymous with "acid-producing", implying the capability to cause water pollution by chemical reaction resulting in increased acidity, low pH, and/or the presence of dissolved iron and other metals. The term does not imply toxicity to humans. See Appendix A for further discussion.

- C. **Overburden Analysis Data:** Premining analysis* of topsoil, overburden materials, and coal pavement is important to determine material characteristics. If potentially toxic materials are found to be present, special overburden handling techniques may need to be included in mine design and operation.

It is recommended that all surface mining in potentially acid-producing areas be within one kilometer (approximately 3,280 feet)' of a rock column that has been sampled and analyzed by approved methods.

If toxic strata are present, a quantitative comparison of alkaline versus acidic materials is suggested. The ratio of the types of strata will be a valuable tool in determining workability of possible techniques for material handling. Standard engineering calculation procedures for earthwork volumes may be adapted for this type calculation.

In addition to acid-base potential, indications as to durability, rock type, color, and other characteristics,** may be useful in certain cases. If mine planning includes use of relatively impermeable layers, materials suitable for that purpose should be identified.

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- D. **Topography and Land Use:** Site topography will be a determining factor in mining and backfilling methodology. To the extent that steepness of slopes is a factor in applicability of certain regulatory requirements for mining and backfilling, it will affect procedures chosen for the site. Planned post-mining land use, particularly in mountaintop removal and area mining, will influence mining and backfilling methods to some extent. These factors must be meshed with plans for handling water and toxic overburden.
- E. **Geologic Considerations:** Geologic characteristics of the site to be mined may involve important considerations in addition to the acid-base potential analysis results.

Dip and strike of the coal should be determined as an indicator of the lay of the pavement subsequent to coal removal.

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- F. **Equipment to be Used in Mining:** The equipment spread is of major importance. An operation utilizing overburden blending will allow flexibility in equipment selection and usage. Material segregation and selective placement may require special equipment considerations.
- G. **Cost:** It is clear that a mining plan must display economic feasibility. Projection of costs will be more important than usual in planning for an operation involving special handling of overburden and other extraordinary expenses.

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*See Appendix A

**See Appendices A and B

1) Smith, R.M. and A.A. Sobek. 1978. Physical and Chemical Properties of Overburdens, Spoils, Wastes, and New Soils in Reclamation of Drastically Disturbed Lands. Am. Soc. Agron., Madison, WI

III. SPECIFIC TECHNIQUES **Table of Contents**

The following items outline some possible means of preventing, minimizing, or correcting water quality problems associated with surface mining.

A. Subsurface Water Handling Measures: Usually, subsurface water will be encountered in the highwall and in or near the coal. We can reasonably expect less such water on the updip side of an area, and more, requiring special attention, on the downdip side.

1. We can utilize the dip of the strata to identify likely areas for subsurface water discharge. In like fashion, we can identify areas where toxic materials may be placed to minimize or prevent contact with water.

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2. Shallow fragmenting of pavement materials may be a useful water pollution control measure, if pavement materials are alkaline. By fragmenting, subsurface water flowing into the backfilled mine site may be directed into and across the alkaline pavement.

3. Where large concentrations of subsurface water are encountered, the pavement may be trenched and/or treated to provide quick routes for water to exit the fill in a planned manner. Non-toxic stone, or durable pipes or culverts may be used in the trench.

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4. Special care in blasting procedures on the last highwall cut may be considered to reduce highwall fracturing and to reduce recharge of groundwater by infiltration.

5. Collection and planned transfer of water from springs is a useful technique to prevent entry of groundwater into toxic materials in valley, head-of-hollow, or other off-bench fills.

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B. Surface Water Handling Measures:

1. Highwall diversions may be an effective means of reducing entry of surface water runoff into the mine site.
2. Transfer of point flows across reclaimed areas in pipes, flumes, or lined channels will reduce erosion and infiltration. Such conveyances could be utilized to conduct uncontaminated water away from or across the job site, rather than allowing this water to enter sediment control or treatment facilities.

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3. Controlled backfilling, grading and shaping of the final surface may be useful to facilitate runoff and reduce infiltration of surface water.

4. On long slopes, terracing or cross ditching may be useful water control measures. Such ditches could be lined with erosion resistant materials, and infiltration should be prevented by use of low permeability materials, if available.

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5. Route earthmoving equipment to achieve fill compaction, especially of outslope areas. Utilize the least permeable materials available as part of the final spoil placement.

C. Overburden Handling:

1. Whereas premining overburden analysis is a valuable tool for mine planning, variability of strata quality should be accounted for during operation. As a job progresses, adjustments to operational procedures may be necessary to insure proper handling of potentially toxic materials. Field clues* to overburden quality and selective testing methods* may be applied by operating personnel on a regular basis.

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2. Proper interpretation of analysis results is necessary. Information pertaining to data interpretation is presented in appendix A to this report.
3. Based upon overburden quality and quantity, a choice between overburden blending, segregation of toxic materials, or a combination thereof, may be made. It is generally felt that blending may be used where the alkaline materials are capable of neutralizing the acidic materials. This determination could be based on study of other mine sites with similar overburden, which are known to have no acidic water problems associated with them, and/or detailed evaluation of the site in question. If blending is used, it should be thorough so as to avoid pockets of potentially toxic materials. Where blending is shown not to be a viable option, segregation and isolation of the potentially toxic zones should be considered as another option. Segregation and isolation may be accomplished by use of the following measures:

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*See Appendix B for discussion of field procedures

- a. Control drilling and blasting to allow material segregation during excavation. In addition, it may be beneficial to keep potentially toxic material in large particles, and to create finer particle size in material with excess alkalinity.
- b. If the coal seam and/or closely associated materials are potentially toxic, the pit should be cleaned prior to backfilling, and before shooting the next adjacent cut. These materials should be removed and handled as other potentially toxic materials.

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4. Place non-toxic material on the floor of the pit, and against the final highwall. It is suggested that the layer on the pit floor be at least four to six feet in thickness, and that the column against the highwall be ten to twenty feet wide. If materials with excess potential alkalinity are available, it may be helpful to incorporate them into these layers.
5. Positive drainage should be provided down the highwall and across the floor of the pit within the layer of non-toxic material. As filling proceeds leave enough room on the outslope side of the fill for a covering of non-toxic material and for surface treatment. Potentially toxic materials should be selectively placed so that they are completely surrounded by non-toxic materials

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6. Final fill of outcrops should be non-toxic material. It is suggested that material close to the surface be finely shot during excavation, or pulverized by tracking with equipment as it is placed.
7. If pavement materials are potentially toxic, acid-preventive measures could be applied. One alternative is to thoroughly and uniformly coat the pavement with a layer of agricultural or hydrated lime, in order to form a seal and prevent contact of water with toxic strata. The intended effect of the lime coating is not to neutralize total potential acidity, but rather to react with iron in the water to create a non-reactive chemical surface atop the potentially acidic material. Conventional agricultural type lime spreaders have been successfully used for such lime application. Other sealers could be used, such as non-toxic clayey soils or weatherable shales, or manufactured sealant materials.

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8. Neutralizing reagents may be admixed with overburden to offset potential acidity of the strata. It is probably not necessary that the lime application rate be adequate to neutralize the total excess potential acidity of the overburden. It is felt that the amount of lime used should be in relation to the calculated immediate lime requirements, with due consideration of strata with excess alkalinity.* Further research and field trials are recommended to establish proper procedures for admixing.

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*See Appendix C

9. Potentially acidic coal refuse placed in surface mine areas may cause future problems, in that such refuse is often much more toxic than overburden, and may greatly complicate water pollution control. It is recommended that an in-depth study of the chemical characteristics of the refuse and of the site conditions be made prior to such disposal.

D. Cut-Throughs Into Deep Mined Areas:

If deep mines are encountered which may affect water quality, study is recommended to adequately consider and arrive at solutions for the potential problem.

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E. Acid Mine Drainage Treatment:

With proper overburden handling it is felt that coal seams with associated potentially acidic overburden can be mined with no water pollution problems remaining after reclamation. However, it is possible that some water with non-complying pH, acidity, iron, or manganese levels may be generated during operational phases when coal and toxic materials are exposed. If this is the case, treatment measures will be necessary to achieve water quality compliance. Treatment methods involving batch handling, such as spraying with lime slurries or hand or drip feeding of neutralizing agents into ponds or channels are suitable if proper care is applied. However, in many cases flow-through treatment units capable of continuous operation could or should be used. Pre-fabricated neutralizing units are on the market which utilize soda ash (Na_2CO_3) in briquette form or sodium hydroxide (Na OH) solution. These units require no electrical power, and have been successfully used in treatment of surface mine discharges. It is possible to construct treatment systems utilizing lime, a less expensive reagent, but a successful lime treatment unit will generally require mechanical feeding and mixing equipment, in addition to bulk storage facilities. Much greater capital cost is incurred than with the soda ash or sodium hydroxide units. An economic analysis of combined capital and operating costs of the alternative systems may be in order for a given situation. The water to be treated should be analyzed, or a valid projection of quality made if system choice is made prior to mining. Water quality may be predicted by data from similar operations in comparable strata. The treatment procedure chosen should fit the water to be neutralized, both on the basis of economics, and with reference to suitability of a particular reagent for contaminants to be handled.

If the only quality problem is low pH, neutralization may be a simple procedure with few operational problems. However, high acidity or excessive levels of iron or manganese may dictate more complex treatment methods and special provisions for settling after neutralization.

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Appendix A

ACID-BASE ACCOUNT

Acid-base accounting is a dependable criterion by which overburden materials can be evaluated. An acid-base account consists of two measurements: (1) total or pyritic sulfur and (2) neutralization potential. The accounting balances maximum potential acidity (from immediately titratable sources plus sulfuric acid equivalent calculated from total sulfur) against total neutralizers (from alkaline carbonates, exchangeable bases, weatherable silicates or other rock sources capable of neutralizing strong acids as measured by the neutralization potentials).

The total or pyritic sulfur content accurately quantifies potential acidity of materials when all sulfur is present as a pyritic mineral. When gypsum is found in an overburden sample or the materials are weathered, sulfur occurs in the form of sulfates. Samples high in organic carbon usually contain organic sulfur. When part of the sulfur occurs in non-acid-producing forms, the maximum potential acidity as calculated will be too high. It is for this reason that such calculations are referred to as maximums and that in doubtful cases appropriate acid and water leachings should be made to rule out those forms of sulfur which do not produce acid. Then from the stoichiometric equation of pyrite oxidation, the maximum potential acidity can be calculated in terms of calcium carbonate equivalent. Overburden material containing 0.1 % sulfur (all as pyrite) yields an amount of sulfuric acid that requires 3.125 tons of calcium carbonate to neutralize one thousand tons of the material. The neutralization potential of overburden materials, the second component of a net acid-base account, measures the amount of neutralizers present in the overburden materials. This measurement is found by treating a sample with a known amount of standardized hydrochloric acid, heating to assure complete reaction, and titrating with a standardized base. The result is then expressed in calcium carbonate equivalents. When balanced against acidity from the total measurement, a net acid-base account can be made.

From the acid-base account, potentially toxic material is defined as any rock or earth material having a net potential deficiency of 5.0 tons of calcium carbonate equivalent or more per 1000 tons of material. (The 1000 tons is based on the assumption that an acre plow-layer contains 2 million pounds of soil). Regardless of the acid-base account, materials which have a pH of less than 4.0 in a pulverized rock slurry in distilled water are defined as being acid-toxic.

The choice of the deficiency of 5 tons of calcium carbonate equivalent per 1000 tons of material as the division between toxic and non-toxic material obviously is arbitrary. However, when applied to the large number of samples studied during the past several years of minesoil research at West Virginia University, it corresponds to other supporting laboratory information about these samples as well as to extensive field experiences with minesoils developing in the different rock types. If rock or soil samples were defined to be toxic at much lower calcium carbonate equivalent deficiencies than 5 tons per 1000 tons, we would be declaring many of our natural soils to be toxic. On the other hand, with deficiencies much greater than 5 tons per 1000 tons, toxic concentrations of plant-available aluminum and pH values below 4.0 often develop rapidly.

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Rock type is incorporated with the acid-base account because it is useful to categorize the materials which comprise coal overburdens. Knowledge of the rock types can provide an estimate of the texture and base status of a future minesoil as well as stability of rock fragments. For example, sandstones containing moderate amounts of pyrite and lacking sufficient neutralizers become active acid producers when exposed to the atmosphere.

Legend for Acid-Base Status Laboratory Work Sheet

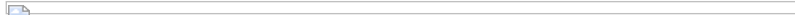
Sample Number-	laboratory sample number.
Depth-	sample interval represented by sample recorded in depths from the surface.
Rock type-	any soil or rock as defined by the following:
Minesoil-	soil formed as a result of mining or mining related activities.
Native soil-	soil that has not been highly disturbed by man.
Horizon 1-	topmost soil layer which is usually darkened by organic matter and has the highest concentration of biological activity.
Horizon 2-	lies between horizons 1 and 3 and is often referred to as the "subsoil".
Horizon 3-	weathered rock or earthy material to consolidated bedrock or a depth of 1.5 m (5 ft.) whichever is shallower.
Earthy material (EM)-	a broad term for any unconsolidated material between a depth of 1.5 m (5 ft.) and consolidated bedrock.
Drift-	a broad term for glacial deposits.
Till-	unsorted and unstratified drift deposited directly by glacial ice.
Outwash (OW)-	stratified and sorted drift deposited from melt-water streams.
Sandstone (SS)-	a sedimentary rock consisting of more than 50 percent sand-size particles.
Mudrock (MR)-	a broad term for a sedimentary rock dominated by silt-size and/or clay-size particles, but which can contain up to 50% sand if properties are dominated by silt and/or clay. Term is used when a rock cannot be definitely distinguished as either a mudstone or shale.
Mudstone (MS)-	a non-fissile mudrock having a moist hardness of less than 2.5 (based on Moh's scale).
Shale (SH)-	a mudrock that appears predominantly fissile. Weathers to form chips.
Limestone (LS)-	a sedimentary rock consisting dominantly of calcium carbonate which must have a moist hardness greater than 2.5 (based on Moh's scale) and a less than 60 mesh powder color value of at least 7. When pulverized to pass a 60 mesh screen, the powder will fizzle freely in 1:3 (acid:water) hydrochloric acid. Magnesium may substitute for some of the calcium forming dolomitic limestone.
Chert, Flint, Jasper-	rocks consisting dominantly of amorphous silica or extremely small (cryptocrystalline) quartz and which have a hardness greater than 6.5 (based on Moh's scale).
Carbolith (Carb)-	a coined name to cover dark colored sedimentary rocksthat will make a black or very dark (Munsell color value of 3 or less) streak or powder. Rocks included under this name include coal not scheduled for mining, impure waste coal, bone coal, high-carbon shales, and high-carbon muds. In general, such rocks contain at least 25 percent carbonaceous matter oxidizable at 350 - 4000 C.
Intercalate (I)-	a term coined to describe rocks which contain at least two different rock types that are so intimately interlayered or "intercalated" that they cannot conveniently be sampled separately. Intercalates have at least three or more layers within a 13 cm (5 in.) measured section. Usually the "I" is followed by two or three of the dominant rock types (e.g. I-SS/ms; I-SS/ms/carb).
Fizz-	a visual numeric estimation showing the presence of carbonates in the less than 60 mesh sample after the addition of a few drops Of 1:3 HCl. 0 = no reaction 1 = very slight reaction 2 = slight reaction 3 = moderate reaction 4 = strong reaction 5 = very strong reaction
Color-	color of the air-dry less than 60 mesh sample based on the Munsell color system of Hue-value/chroma.
% S-	percent sulfur in the sample as detected by a LECO induction furnace.
Max. from %S-	maximum amount of acid that can be produced from %Sulfur present in sample expressed in terms of CaCO ₃ equivalents in Tons/1000 Tons of material. Derived from multiplying %S by 31.25.
Amount present-	amount of neutralizers present in sample expressed in CaCO ₃ equivalents in Tons/1000 Tons of material as determined by the neutralization potential (NP). Negative numbers indicate the presence of free acid.

- Maximum needed (pH7)*- amount of neutralizers required to neutralize the maximum acidity possible from %S in Tons/1 000 Tons of material.
- Excess*- excess neutralizers present in Tons/1000 Tons of material after acid has been neutralized.
- H2O slaking- a visual numeric estimation of the percentage of rock breakdown when the rock is placed in water. It ranges from 0 (0%) to 10 (100%) breakdown.
- Paste pH- pH of sample from soil-distilled water paste.

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*Both the maximum needed (pH 7) and excess neutralizers are derived from subtracting the maximum from %S from the amount present. If the resulting number is negative, it is listed under the maximum needed(pH 7) column; if positive, it is listed under the excess column.



Typical Acid-Base Analysis Reporting Form

Lab Date _____		Site _____		No. of Samples _____		CaCO ₃ EQUIVALENT TONS/1000 TONS OF MATERIAL				
SAMPLE NUMBER	DEPTH (FEET)	ROCK TYPE	FIZZ	COLOR	%S	MAX. FROM %S	AMT. PRESENT	MAX. NEEDED (pH 7)	EXCESS	PASTE pH

Legend for Nutrient Status Laboratory Work Sheet

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Sample number-laboratory sample number.

1:1 pH-pH from 1:1 (Sample: water) ration

L.R.-lime requirement in Tons/acre to acquire a pH of 6.5.

K*-amount of acid extractable potassium in sample in lbs./1000 Tons of material.

- 0 - 60 Low
- 61 - 120 Medium
- 121 - 240 High
- 241 - Very High

Ca*-amount of acid extractable calcium in sample in lbs./1000 Tons of material.

- 0 - 1000 Low
- 1001 - 2500 Medium
- 2501 - 4000 High
- 4001 - Very High

Mg*-amount of acid extractable magnesium in sample in lbs./1000 Tons of material.

- 0 - 100 Low
- 101 - 250 Medium
- 251 - 500 High
- 501 - Very High

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Bicarb. extr. Phos.**-amount of bicarbonate extractable phosphorous in sample in parts per 2 million (pp2m). Note: pp2m. = lbs./1 000 Tons of material.

- 0 - 10 Low
- 10 - 20 Medium
- 20 - High

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-Ratings for the given numerical values are those currently being used by West Virginia University Soil Testing Laboratory.

**Ratings for the given numerical values are from Jackson, M.L. 1958. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J.



Typical Nutrient Status Report Form

Lab Date _____ Site _____ No. of Samples _____

Sample Number	Ton/Acre		Lbs./1000 Tons of Material			PP2M Bicarb. Extr Phos.
	1:1 pH	L.R.	K	Ca	Mg	

Interpreting Soil Tests for Mine Soil Revegetation

A color chroma reading is sometimes included because there is a general relationship between chroma and pyritic sulphur. Higher chromas (higher than 2) commonly are associated with lower total and pyritic sulphur and less potential acidity. Note: These relationships do not apply to overburden materials dominated by basic carbonates.

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Lime and fertilizer expressed as tons or pounds per acre means the same as tons or pounds per 1000 tons of soil or rock material.

One ton of pulverized limestone is equivalent to 800 pounds of calcium per acre.

When magnesium is lower than 50 pounds per acre plants are likely to suffer from deficiencies unless magnesium fertilizer is applied or limestone containing magnesium is used. At least 100 pounds of magnesium is desirable.

Limestone needed refers to immediate acidity, unless an allowance is made for acidity that may form from oxidation of pyrite.

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Fifty pounds of nitrogen is recommended, generally, to help assure prompt early growth and ground cover by grasses or other non-legumes. This means that 100 pounds per acre of 33-0-0 should usually be applied to new seedings on minesoils in addition to standard soiltest recommendations, especially where erosion is serious.

Phosphorus (P) recommended is sufficient to raise the available level to 50 pounds per acre. However, maximum growth rates may require as much as 100 pounds per acre (220 pounds of P205). Conversion, P to P205 is $2.29 \times P$; P205 to P, the conversion is 0.436.

Potassium (K) recommended is sufficient to raise the available level to at least 100 pounds per acre. Maximum growth rates may require 150 pounds per acre (180 pounds of K20). Conversion K to K20 is 1.2 and from K20 to K is 0.83.

Procedure for Logging and Sampling Overburden Cores for Chemical Analysis

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A. General

1. There are 3 basic means of obtaining overburden data from rock strata; core sampling, highwall grab samples, and rock chip (air drill) samples.
 - a. When using cores for overburden analysis, the cores should be wrapped in plastic or protected from the weather and stored in a dry place, preferably in wooden or cardboard boxes.
 - b. When highwall samples are collected from each stratum, fresh highwall exposure renders the most accurate results. Full pint containers of each sample are of adequate size for preparation and representation.
 - c. When obtaining samples from an air drill hole, place a shovel adjacent to the hole while the drill is in operation and with the aid of the drill operator, estimate 1 foot intervals and transfer sample to pint containers. The samples can be comingled in the preparation room if they are of the same strata.

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B. In the Field

1. All pertinent information about the core is recorded.
 - a. Location
 - b. Total length of core
 - c. Coal seams involved
 - d. Depth from land surface to top of core
 - e. Elevation of land surface
 - f. Any physical irregularity (e.g. encounter of extremely hard stratum between 57 - 64')
2. Sampling and logging starts from top of core. Note: see Typical Core Breakdown for Chemical Analysis
3. The core is divided into the six rock types; sandstone shale, mudrock, limestone, intercalate, carbolith, and chert. The rock type and its thickness are recorded along with color (red, green, etc.), fossils (plant or animal), slicken sides (prominent or present), nodules, and any other descriptive information which can be observed.

**Typical Core Breakdown
for Chemical Analysis**

SAMPLE NUMBER	SAMPLE INTERVAL	DESCRIPTION
1	0-3'	Tan fine grained sandstone, with pinkish tint, very hard
2	3'-6'4"	same as above
3	6'4"-10'	Gray, medium grained sandstone with visible biotite and quartz crystals; few carbolith streaks
4	10'-14'	same as above
5	14'-18'	same as above
6	18'-23'	Light gray, medium grained sandstone with few carbolith streaks; section contains oxidized fracture planes
7	23'-27'	same as above
8	27'-31'	same as above
9	31'-35'5"	same as above
10	35'5"-40'	Light tan fine grained sandstone with (weathered) brown fragments and clay nodules, few carbolith streaks
11	40'-45'9"	Gray medium grained sandstone with carbolith streaks
12	45'9"-49'10"	same as above
13	49'10"-51'	Dark gray shaley sandstone with carbolith fragments
14	51'-55'	Gray medium grained sandstone with carbolith streaks
15	55'-59'6"	Medium gray sandstone with many carbolith streaks
16	59'6"-61'6"	Dark gray shale with visible bedding planes
17	61'6"-65'	same as above
18	65'-69'	same as above
19	69'-73'	same as above
20	73'-77'	same as above
21	77'-81'	same as above
22	81'-85'	same as above
23	85'-88'5"	same as above
24	88'5"-92'6"	Firm medium gray sandy shale
25	92'6"-94'	Dark gray shale with sandy sediment streaks
26	94'-97'	coal (Gilbert seam)
27	97'-102'5"	Gray shale with sandy sediment streaks
28	102'5"-107'	Gray sandy shale

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C. In the Preparation Room

1. Using the drillers log, the core can easily be subdivide for grinding and chemical evaluation.
2. Each individual stratum is pulverized (60 mesh) separately, using the following guidelines.
 - a. If a rock member is less than 1 foot, it is logged but not sampled unless it is a layer of special interest, e.g. containing visible pyrite limestone, coal, etc.
 - b. If the rock member is of considerable thickness, e.g. 30 feet, the number of samples taken from this section depends on rock type. Sandstones, intercalates, and chert are normally sampled every 5 feet; wile shale, mudrock, limestone, or carbolith would be sampled every 3 feet. Therefore, 6 and 10 samples, respectively, would be taken in that particular stratum.
 - c. If a rock stratum is not of even incremental thichness, e.g., 8 feet of sandstone, the stratum should be sampled from 0-4' and 4-8'.
 - d. When an obvious change is in properties, such as penetration of the weathered zone below the land surface, occurs at a point within a rock type, the two zones are recorded and sampled as different rack members.

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3. After Proper subdivision, each entire sample unit is pulverized to pass a 10 mesh (2.0 mm) sieve.
4. The sample is then riffled to obtain a representative sample of approximately 500 gms., and then dried at 50-60°C overnight.
5. Following air drying, the sample is pulverized to pass a 60 mesh (0.25mm) sieve, riffled to approximately 100 gms., and

retained in 4 oz. sample bottles.

- The remaining sample is retained in appropriate labeled containers and stored in a dry and convenient area for future referral.

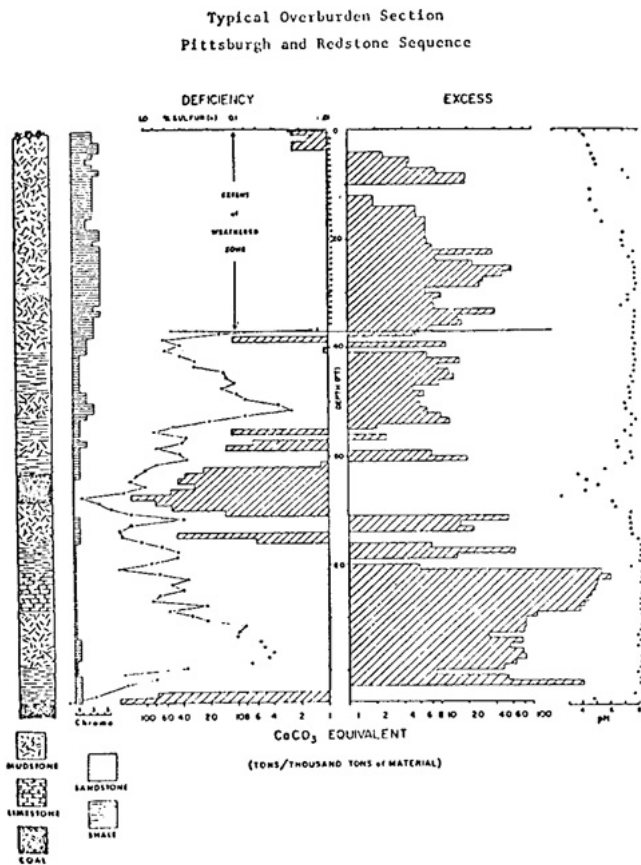
D. In the Laboratory

After the samples are pulverized they are ready for chemical evaluation. All samples should be analyzed for pH, fizz, total sulfur, and neutralization potential. Additional parameters may be required for those samples which are to be placed on the surface after regrading such as calcium, magnesium, potassium, phosphorous, and lime requirements. Other physical properties which in some cases should be looked at are water holding capacity and mechanical size distribution.

Table Contents

For the most part, percent sulfur (%S), and neutralization potential (NP) are the parameters which are the governing factors when looking for potentially toxic overburden.

Laboratory procedures for the parameters can be found in EPA Bulletin EPA-600/2-78-054, "Field and Laboratory Methods Applicable to Overburden and Mine Soils" pages 45-99.



Appendix B Table Contents

Condensed Guide to Field Clues

Tools:

- Dropper bottle containing 10% HCl (1 cc of conc. HCl in 3 cc of water).
- Munsell Soil Color Charts; one page of Hue 10 YR is usually adequate.
- 10X hand lens.
- Pocket knife, or other tool to scrape powder from rock surface.
- Hammer, to break rock fragment exposing fresh face for observation.
- Porcelain Streak plate.

Table Contents

Observations and Interpretations:

- Sample fizzes when dilute hydrochloric acid is applied-material probably contains over 2% calcium carbonate; a positive test usually indicates favorable material.
- Pyrite crystals observable by the unaided eye, or under 10 X lens -likely to be potentially toxic, especially if carbonates are absent.

- C. Powder color Value of 3 or less -high carbon content; indicates probable high pyrite content even if not readily visible; likely to be potentially toxic if carbonates are absent.
- D. Powder color Value of 4 or higher -not a true "black shale"; probably not potentially toxic unless pyrite is visible and powder does not react with acid indicating the presence of carbonates.
- E. Rock or powder color Chroma of 2 or less - as applied to rocks deeply buried in an undisturbed section, indicates iron is not oxidized (unweathered rock); pyrite may be present; presence of significant amounts of carbonates may override the influence of pyrite as a potential acid former.
- F. Rock or powder color Chroma of 3 or higher - indicates significant iron oxide staining, indicative of probable absence of pyrite because of prior oxidation and weathering over geological time. Material may contain neutralizers, but most probably will require lime and fertilizer to restore nutrient content if used as mine soil surface material.
- G. If steel knife scratches a rock fragment, the rock hardness is 5 or less. If the knife will not scratch the rock, then the hardness is greater than 5.
- H. If a fingernail will scratch a rock, record the rock hardness as less than 2.5. As a general rule the harder a rock (the higher the number) the more resistant it will be to physical weathering.

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Notes:

1. Only laboratory analyses will confirm the composition of materials.
2. The most meaningful field observations are made on the freshly exposed surface of a broken rock fragment or a fresh highwall exposure, rather than a hand sample casually picked up which may have extraneous surface contamination or changes from exposure to weathering forces.
3. Care must be taken to insure that the rock mass is being cut and not that sand grains are being pried loose when a hardness "standard" (finger-nail or steel knife) is scratched against the rock fragment. This is especially true with sandstone.

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References:

- (1) Grube, W. E., Jr. and R. M. Smith. 1974. Field Clues Useful for Characterization of Coal Overburden. Green Lands Quarterly. 4(1):24-25.
- (2) Sobek, A. A., W. A. Schuller, J. R. Freeman and F. M. Smith. 1978. Field and Laboratory Methods Applicable to Overburdens and Mine soils. Environmental Protection Technology Series. EPA-600/2-78-054. U.S. Environmental Protection Agency. Cincinnati, Ohio.

Laboratory Measurements

The following tests have proven useful for mine soils and overburdens in West Virginia.

A. Routine

1. Color value and chroma.
2. Paste pH.
3. Fizz test for carbonate neutralizers.
4. Neutralization Potential.
5. Total sulfur percentage and conversion to acid.
6. * Immediate lime requirement.
7. * Available plant nutrients by Double Acid Extraction.
8. * Available Phosphorus by Alkaline Extraction.

* If topsoil substitution is anticipated.

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B. Selective

1. Properties of Hardness and Cementation
2. Water slaking or breakdown (mild simulated weathering)
3. Physical Weathering Potential (vigorous simulated weathering)
4. Electrical Conductivity (mainly in western coal basins)
5. Porosity and Density of Rocks or Soils
6. Weathering Yard Breakdown
7. Moisture Retention
8. Texture
9. The following tests have proven useful for mine soils and overburdens in West Virginia.

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References:

- Sobek, A. A., W. A. Schuller, J. R. Freeman and R. M. Smith. 1978. Field and Laboratory Methods Applicable to Overburdens and Mine soils. Environmental Protection Technology Series.

Appendix C

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Immediate Lime Requirement

Total sulfur analysis includes sulfide (pyritic), organic and sulfate sulfur. Sulfur in the pyritic form is responsible for the toxic acid production from coal overburden materials. High chroma (brown) material may contain appreciable amounts of sulfates, and low color value (black when powdered) materials almost always contain organic sulfur. Therefore, total sulfur analyses will generally over-estimate the total potential acidity of the overburden materials.

Total pyrite weathering may occur over a long time period, and if the potentially toxic material is quickly covered to decrease the air and water supply, the pyrite may never completely oxidize or weather to produce acid. Also, complete neutralization (pH 7.0) is not needed for most purposes. A pH of 5.5 is satisfactory for many land uses and it will insure non-toxic water. Therefore, it is realistic to attempt to neutralize only a fraction of the calculated total potential acidity by lime applications.

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Immediate lime requirement is considered to be the titratable acidity or the negative neutralization potential (amount present column on the laboratory sheet). A reasonable safety factor for immediate lime requirement is 2 times the negative NP.

Some samples have a positive but low NP, and they also have high total sulfur values. In this situation, the maximum potential acidity from pyritic sulfur should be used to determine lime requirement. A realistic lime requirement figure is probably a third of the maximum potential acidity from total sulfur.

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If the overburden has strata with excess bases, no lime will normally be needed if this material is well mixed with the deficient material. The tons of excess CaCO₃ equivalent in the total overburden section and the calculated lime requirement should be mathematically compared to determine if admixing of lime is actually needed. Particle size plays an important role at this point. As the particle size of the basic material gets finer, more reactive surfaces are exposed and quicker neutralization of acid takes place. Concurrently, the potentially toxic material should have as large a particle size as possible to reduce acid production.

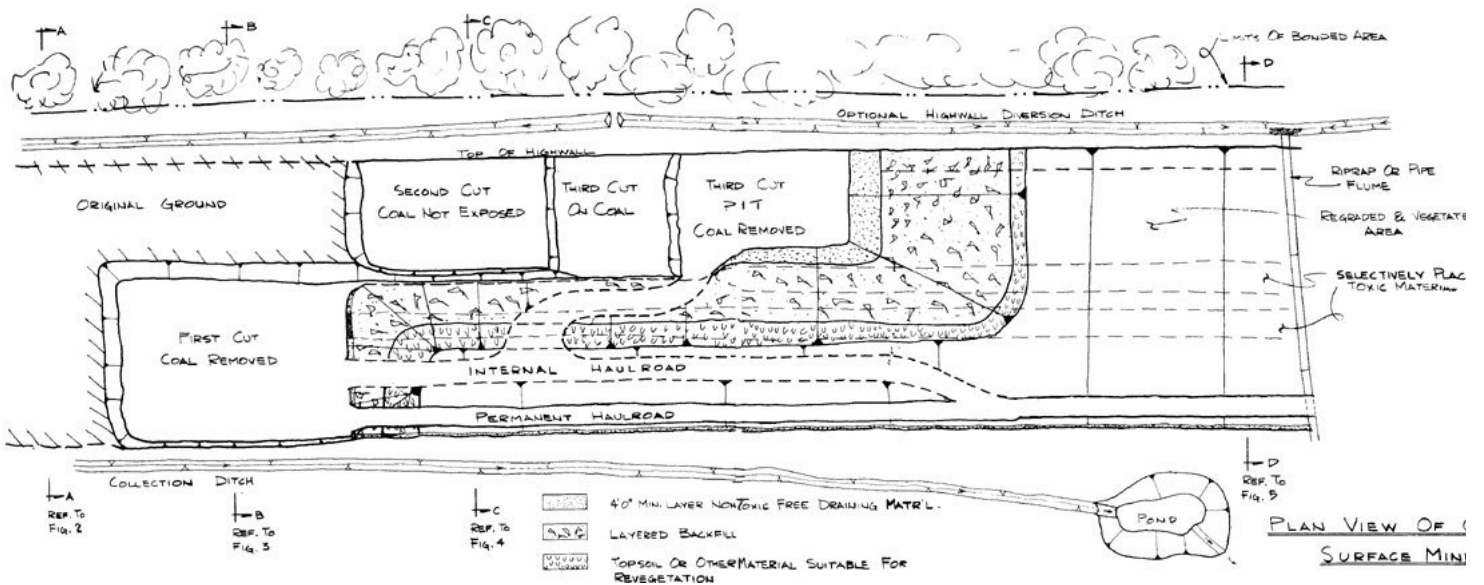


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Appendix D

Effluent Monitoring Parameters Used For Mine Drainage

pH: pH is the logarithm of the reciprocal of the hydrogen ion concentration. pH expresses the intensity of the acid or alkaline reaction of a solution in terms of the hydrogen ion concentration, but it is not a measure of the total concentration of acid or alkalinity present. The practical pH scale extends from 0, very acidic, to 14, very alkaline, with the middle value (pH 7) corresponding to exact neutrality at 25°C. Presence of strong acids such as sulfuric or hydrochloric markedly reduce the pH value while an equal amount of weak acid, such as carbonic acid, only slightly lowers the pH value.

Similarly, alkali increases the pH value to above 7.0 and the degree of change depends on the intensity and the amount of alkali present. pH value below 7.0 indicates acidity; pH value of 7.0 indicates neutrality; pH value of more than 7.0 indicates alkalinity.

State pollution control regulations require all discharges to have a pH of between 6.0 and 8.5, while the Federal Office of Surface Mining requires the pH to be between 6.0 and 9.0.

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TOTAL SUSPENDED SOLIDS: Total Suspended Solids is defined as the sediment that is in suspension in water but that will physically settle out under quiescent conditions.

This is determined by filtering a sample through a standard glass fibre filter. The results are expressed in parts per million. The results do not signify the type of pollutants in the water.

Suspended solids eventually settle at the stream beds and reduce the hydraulic capacity of the streams and increase flooding potential. Muddy water affects fish by interfering with their breathing, feeding and reproduction.

OSM regulations for effluent limitations specify maximum allowable total suspended solids concentrations of 70 parts per million and average daily values for 30 consecutive discharge days to be 35 parts per million.

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IRON: Iron is a metallic element which is found in abundance in the earth's crust.

Iron's importance is derived from the stains of "yellow boy" imparted to the stream beds. Soluble iron in the water supply also imparts stains to laundry and porcelain and has a bittersweet taste. Excessive iron concentrations are also considered lethal to fish.

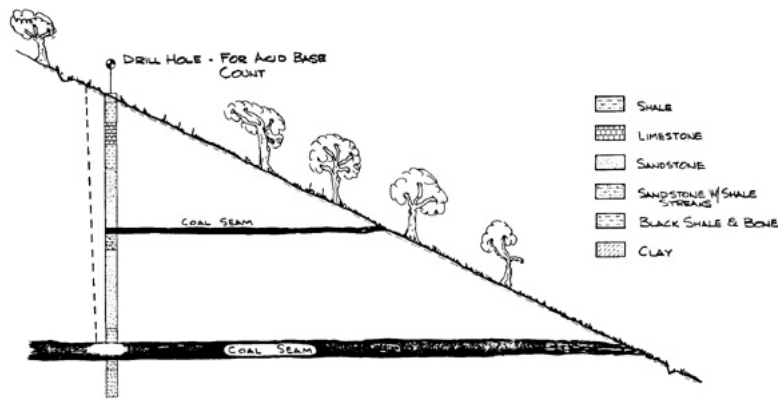
Total iron concentrations are generally determined by either atomic absorption spectrophotometer or colorimetric equipment.

OSM regulations for effluent limitations specify maximum allowable total iron concentrations of 7.0 parts per million and average daily values for 30 consecutive discharge days to be 3.5 parts per million.

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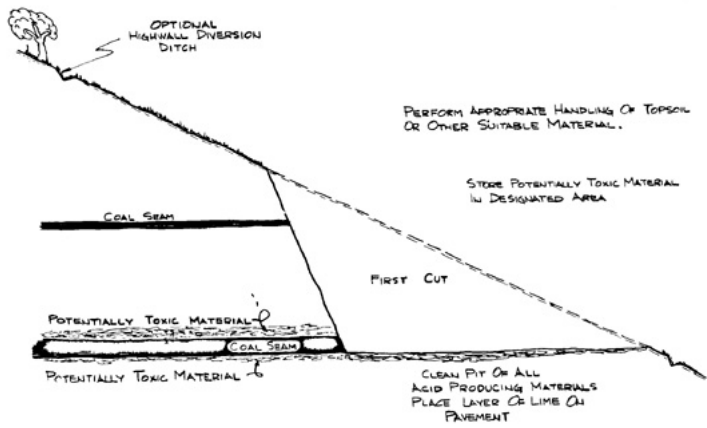
MANGANESE: Manganese is a metallic element which, with few exceptions, exists in the divalent manganous state.

Manganese imparts stains to laundry and porcelain. Excessive manganese concentrations are considered detrimental to aquatic life.



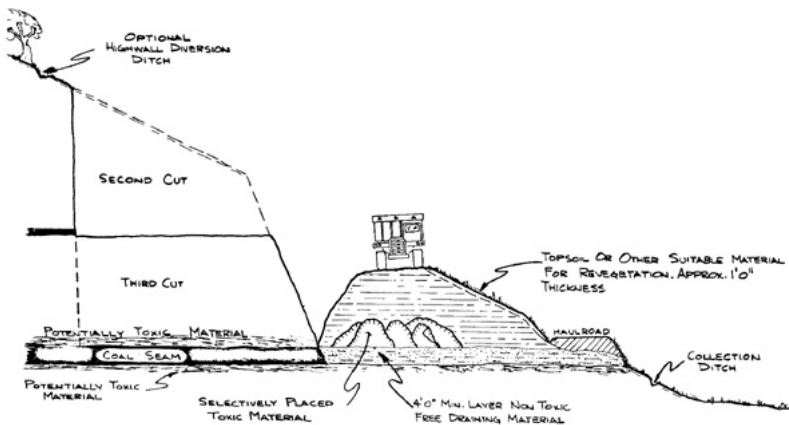
ORIGINAL GROUND
SECTION A-A
DRAINAGE SYSTEM IS TO BE INSTALLED
BEFORE MINING OPERATIONS BEGIN
FIGURE 2

DWG. P-2 DJS/MLK

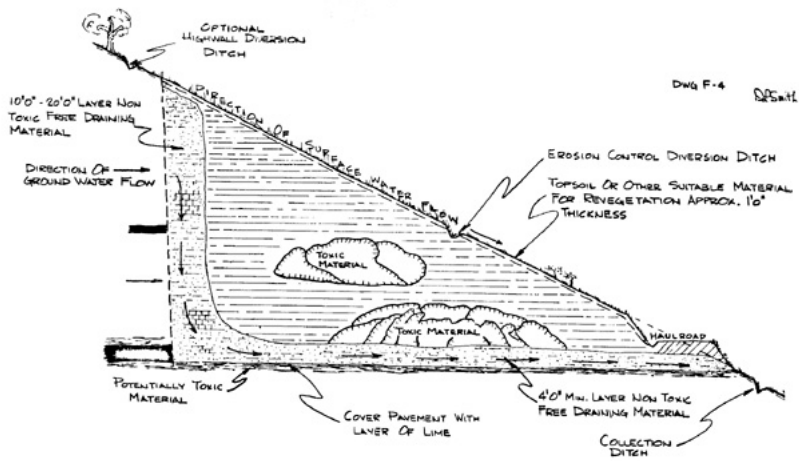


FIRST CUT
SECTION B-B
FIGURE 3

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SECOND CUT
SECTION C-C
FIGURE 4



BACKFILL & REGRADING PLAN
SECTION D-D
FIGURE 5

DWG F-4 QPS/HL

DWG F-5 QPS/HL

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Total manganese concentrations are determined by atomic absorption spectrophotometer or colorimetric equipment. Manganese concentrations are expressed in parts per million.

OSM regulations for effluent limitations specify maximum allowable total manganese concentrations of 4.0 parts per million and average daily values for 30 consecutive discharge days to be 2.0 parts per million.

ACIDITY: Acidity is defined as the capacity of water to donate protons. It is also known as the quantitative capacity to neutralize a strong base to a designated pH.

Acidity is significant because it affects aquatic life; contribution to corrosion is also a factor.

Total acidity is determined by titrating water samples with an alkaline solution of known concentration. It is expressed in parts per million.

OSM regulations have no standards for acidity. Federal NPDES permits normally require acidity monitoring.

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ALKALINITY: Alkalinity is the capacity of water to accept protons. It is also known as the quantitative capacity to neutralize a strong acid to a designated pH.

Alkalinity is usually imparted by the bicarbonate, carbonate and hydroxide ions. Stream water quality standards require that alkalinity be higher than acidity at all times. Alkalinity provides a buffer against acid discharges.

Alkalinity is determined by titrating a water sample with an acid solution of known concentration. It is expressed as parts per million.

OSM regulations have no standards for alkalinity. Federal NPDES permits normally require alkalinity monitoring, and specify that total alkalinity must exceed total acidity in water discharged.

NOTES

Table Contents