MUDDY RUN

MINE DRAINAGE POLLUTION

ABATEMENT PROJECT

OPERATION SCARLIFT

COMMONWEALTH OF PENNSYLVANIA

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APPENDIX

APPENDIX A
CONCEPT PAPER
ON THE PROPOSED USE
OF
LIMESTONE IN STRIP MINE RECLAMATION

The surface or strip mining of coal continues to be a principal method of acquiring coal. Its importance is increasing as new deep mine safety laws and economic factors make strip mining a more attractive alternative to deep mining.

It is generally believed that prevention of strip mine pollution can best be accomplished by requiring contour or terrace backfilling of the strip cut. Such. a requirement, together with segregation and burial of acid-forming materials, preserving and replacing as much topsoil as possible, surface water diversion, and, finally, tree planting, has reportedly been successful in preventing pollution from most post-1963 strip mines in Pennsylvania. These reclamation procedures accomplish the following:

(1) The acid-forming material is buried deep in the cutwhere the possibility of complete inundation by rising groundwater is excellent. Such inundation essentially eliminates fur there acid formation.

(2) Contour or terrace backfilling and surface water diversion

improves surface water runoff conditions and increases resistance to ground water movement, thereby raising the ground water level.

(3) The replacing of topsoil, where possible, is very important. It provides a media for surface vegetation growth and increases the water retention capabilities of the upper surface of the spoil, thereby reducing the amount of water percolating through the spoil. Just as important, it provides the organic activity necessary for increased carbon dioxide production. This CO_2 is then dissolved by precipitation, forming a slightly acid water to percolate through the clean backfill (which contains calcium carbonate), dissolving the $CaCO_3$ and resulting in alkaline, buffered water. Such water is less likely to become acid if it contacts acidic material deeper in the backfilled strip cut. (a)

(4) Tree planting ultimately results in re-establishment of root systems to retard erosion and reduce the amount of water in the backfill by utilizing water in growth and transpiration.

[a] "An Evaluation of Factors Affecting Acid Mine Drainage Production and the Ground Water Interactions in Selected Areas at Western Pennsylvania". Caruccio, Frank T. , Second Symposium on Coal Mine Drainage Research, May 1968.

However, planting of grasses is much quicker and more effective in accomplishing the same result. Grasses also increase the amount of soil by adding organic matter and by gradually breaking down the upper layer of spoil into a soil profile.

Unfortunately, all of the above reclamation measures cannot be readily applied to old strip mines, because the segregation of acid forming material and preservation of topsoil must be accomplished during the mines' operation. Up to now, the strip mine reclamation measures available for pre-1963 mines have been contour or terrace backfilling (often including repair of ruptured low walls); surface water diversion via highwall ditches; and liming, fertilization and seeding of the surface to encourage grass growth. The success of these measures has been only superficially observed and not carefully monitored and evaluated. It does not appear that enough examples of old strip mine reclamation are available, particularly in alkalinity-poor watersheds, to conduct a meaningful evaluation.

Limestone Reclamation

There is less probability of success in backfilling and planting old strip mines than in reclamation of currently active strip mines. This is principally due to the mixture of acid refuse in the overburden and the irretrievable loss of topsoil. On Alder Run in Clearfield County and on other alkalinity-poor watersheds the problem is compounded due to the lack of calcium carbonate or other alkaline sources. The problem is further complicated by the stony nature of the spoil associated with the principal acid coal seams ("A" and "B ") in the Alder Run and Muddy Run water-sheds. This material leaves an extremely poor surface for revegetation upon regrading. It is because of these conditions that it is proposed to limit backfill to that required to enhance surface runoff and control erosion. The cost savings would be devoted to heavy limestone treatment of the surface, fertilization, some limited topsoil application, where necessary, and planting of grasses.

There are other important practical advantages to "limestone" reclamation. Many old strip areas have developed excellent tree growths on some portions of the disturbed areas while other portions remain "hot" and devoid of vegetation. The reduced amount of earth moving required when limestone reclamation is undertaken allows borrowing of fill from non-vegetated areas. The areas that have excellent tree growths can be left undisturbed except for application of lime, fertilizer and seed to accelerate vegetation growth.

Another advantage is that in some areas a well developed grass growth will encourage use of the land for pasturing cattle. The manure from the cattle will also accelerate surface recovery.

Application' to Alder Run and Muddy Run Watersheds

The polluting strip areas in the Alder Run and Muddy Run watersheds are mainly in the highly acid "A" (Clarion) and "B" (Lower Kittanning) seams situated in the headwater regions. The spoil types are well mixed in these unreclaimed strip mines and spoil segregation and burial is no longer possible. There are no concentrations of "soil type" material in existence and it is unlikely that any soil can be reclaimed in the regrading process. The acid water emanating from these strip mines is produced from varying contributions from three (3) sources:

(1) Percolating meteoric water;

(2) Ground water entering from adjacent recharge areas; and

(3) Deep mine water entering from adjacent deep mined areas .

The acid produced within a strip mine is caused by the oxidation of iron disulfide both on the surface and within that part of the spoil above the water table. The subsequently formed iron sulfate is dissolved mainly by percolating meteoric water, and to a minor degree by the rising cycle of normal water table fluctuations. The polluting percolating water (during periods of rainfall) mixes with the standing water in the spoil, then slowly discharges to the surface drainage at various points around the toe of the spoil site.

There is no soil in these areas to place on top of the regraded surface. The stony material forming the top layer of the strip will be both (1) of the same general chemical composition as the old surface, and (2) as permeable (to both air and water) as it was prior to regrading. Since there will be little soil, trees are the only vegetation that can be established. The trees will protect the area from erosion and will intercept some of the percolating water for their life function. Trees do not rapidly form a soil profile, as is evidenced by other strips in the watersheds that were reforested as much as 30 years ago. The surface of the reforested strips is almost as stony as the surface of the new unreclaimed strips. The minor difference in stoniness is probably due to prolonged surface exposure rather than from any action of the trees. Rainfall and air still have an easy access to the spoil material, and acid seeps still occur along the toe of the spoil material in the reforested strips in this area. It is obvious, in these cases, that regrading and reforestation have less than the desired effect in pollution abatement. Artificial sources of alkalinity must be introduced into the basin. Limestone is the cheapest and most readily available source of alkalinity; however, it cannot be introduced into acid water, for the precipitating products of neutralization will coat it and quickly render it ineffective The limestone must be introduced in the water before the water contacts the iron disulfide.

It is suggested, then, that an application of limestone be integrated with minimal regrading to achieve effective abatement. Regrading should be done only to the extent needed to assure slope stability, facilitate runoff, and control erosion. The money saved by utilizing this minimal regrading concept versus contour or terrace methods can be funneled into a limestone application program. In fact, it is estimated that enough money can be saved on regrading to cover the complete cost of the limestone application.

Quarry limestone (Class 2RC) is recommended for use. It is a cheap ($1.15 per ton by bulk, $2.80 delivered) and highly suitable limestone for this purpose. It is an aggregate of particle sizes ranging from dust to 3/4 inch. It is recommended that an average layer of one inch thickness be spread over the entire strip. This translates to approximately 200 tons of limestone per acre. In practice this limestone will not be evenly distributed, but will be spread thicker in areas of thick spoil and maximum recharge. The limestone is to be spread at the completion of grading and will be disked into the top layer of spoil.

The purpose of the limestone is many-fold. The presence of this relatively fine grained material will decrease the stoniness of the top layer,. making it more acceptable for grass growth. This limestone will keep the top layer alkaline for many years, allowing grasses to become well established.

The ability of water to dissolve limestone is directly related to content of carbon dioxide in the water. Rainwater is low in CO_2, but after passing through a soil horizon it is greatly enriched in CO_2. This high $C0_2$ percolating water will then dissolve limestone from the top layer. The very fine grained limestone will be dissolved soon after it is applied. This will cause an initial spike of alkalinity to be introduced into the spoil, achieving a desired pH. This high pH will be maintained as more rainwater enters the spoil. Alkalinity in the spoil serves four basic functions:

(1) It will neutralize the already acid water in the pile.

(2) It will add alkalinity to the groundwater entering the spoil.

(3) It will slow down the oxidation of pyrite by reducing and possibly eliminating the bacteria that catalyze iron disulfide oxidation. These catalyzing bacteria do not thrive in

a high pH environment.

(4) If there is any alkalinity in excess of that needed to neutralize the water in the spoil it will enter the surface drainage in a headwater area to provide much needed neutralization downstream.

It is not intended for the limestone to be present in the spoil forever, but only to keep conditions favorable long enough for nature to provide the permanent cure. Through time the amount of alkalinity entering the spoil will decrease as the finer grained limestone is consumed, but at the same time the vegetation will be becoming better established and a soil profile will be forming which will decrease the air and water entering the spoil. It will retain more water, which will be both evaporated and transpired back to the atmosphere, never contacting the spoil. This soil cover will also form a more effective air seal for the spoil, decreasing the influx of oxygen needed to oxidize the pyrite.

Summary

The use of substantially increased quantities of limestone in reclaiming strip mines in alkalinity-poor watersheds should prove preferable to complete backfilling and limited surface treatment. The cost of the limestone can be essentially defrayed by limiting backfilling to only that degree necessary to improve surface runoff and reduce erosion.

The limestone will reduce formation of acid from-the reclaimed strip area, aid in neutralization of residual acid, and will greatly accelerate rejuvenation of the surface to reduce water percolation through the reclaimed strip area.

BY

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APPENDIX B

WATER QUALITY CRITERIA

Specific water quality criteria which has been established by the Department of Environmental Resources for this area of the West Branch Susquehanna River is as follows:

pH - Not less than 6.0 and not more than 8.5.

Dissolved Oxygen - Minimum daily average 6.0 mg/L; no value less than 5.0 mg/L. For lakes, ponds and impoundments only, no value less than 5.0 mg/L at any point.

Iron - Total iron not more than 1 .5 mg/L.

Temperature - Not more than a 5^0 F. rise above natural temperatures or a maximum of 58^0 F.

Dissolved Solids - Not more than 500 mg/L as a monthly average value; not more than 750 mg/L at any time.

Bacteria (Coliforms/100ml) - For the period 5/15 - 9/15 of any year, not more than 1 , 000/100 ml as an arithmetic average value; not more than 1 , 000/100 ml in more than two consecutive samples; not more than 2,400/100 ml in more than one sample.

Aluminum -Not more than 0. 1 mg/L.

Ammonia Nitrogen - Not more than 0.5 mg/L.

Total Manganese - Not more than 1 .0 mg/L.

Sulfate -Not more than 250 mg/L or natural levels, whichever is greater.

NOTE: Data obtained from Mr. Theodore P. Clista, Susquehanna River Basin Engineer, Department of Environmental Services

APPENDIX C

DEFINITION OF TERMS

Airway - An air passage, usually vertical or near vertical, which provides for the ventilation of a mine.

Artesian -Groundwater under sufficient hydrostatic head to rise above the aquifer containing it.

Axial trend - Strike of the axial plane of a fold.

Biotic transpiration - Loss of water vapor from plants.

Bony - Slaty coal or carbonaceous shale, high in inorganic material, coal waste.

Coal structure contour -A contour line down through points of equal elevation on the coal bed or horizon, in order to depict the attitude of the rocks.

Deep mine - As distinguished from a strip mine is a mine that has a roof composed of natural, in-place overburden material.

Dip - The angle at which a bed, stratum or vein is inclined from the horizontal.

Drift - A deep mine entry driven directly into a horizontal or near horizontal coal seam or vein where it outcrops or is exposed at the ground surface.

Fold axis -The line following the apex of an anticline or the lowest part of a syncline.

Grout curtain -Foreign material (generally cement) inserted through bore holes under pressure into rock units to decrease permeability of the units.

Gurley meter - A mechanical instrument that measures the velocity of a fluid at any point of insertion.

Head (of water) - Pressure of the fluid upon a unit area due to the height at which the surface of the fluid stands above the point where the pressure is determined.

Hoisting shaft - A near vertical mine entryway used for conveying men, materials and coal into and out of a deep mine.

Meteoric water - That which occurs in or is derived from the atmosphere (rainfall).

Paleoenvironment - The environment of an area at some specified time in the distant past.

Portal - Surface entrance to a mine, particularly to a drift, tunnel, or adit.

Shaft - A near vertical mine entrance extending downward from the surface or from some interior point as a principal opening through which the mine is exploited. It may be used in connection with hoisting men, rock and supplies, or for pumping or ventilating operations.

Slope - An inclined mine entryway driven down to the seam.

Strike - The direction of a horizontal line on the plane that is tangent to the surface of stratum at the point of measurement. The direction of strike is perpendicular to the direction of dip.

Strip mine - An open working in which the materials overlying the minerals are removed in order to extract the mineral.

Tap-off - A discharge mechanism (generally a bore hole) used to regulate mine pool elevation.

Tipple - Structure above a mine shaft, particularly a coal mine, in which loaded mine cars are emptied by being tipped over.

Wrench fault - A strike-slip fault whose plane is nearly vertical and the movement along which was basically horizontal.