SECTION VII

ABATEMENT METHODS

Various abatement measures have been studied to reduce or eliminate mine drainage originating within the Licking Creek Watershed. Possible solutions for this problem include chemical and physical treatment of polluted runoff waters, and source abatement by numerous techniques designed to prevent the formation of acid or its transport from the mined area, including deep mine sealing, acid spoil burial and regrading and revegetation of strip mines.

A number of methods have been studied for the treatment of acid mine drainage waters. The greatest advantage of treatment is that it has been proven to produce stream water that will support normal aquatic life. However, this approach has a number of serious disadvantages: (1) without constructing a treatment plant on every polluted tributary, total abatement cannot be achieved; (2) fluctuation of stream flow at the treatment site is so great that a plant capable of handling peak flows would be operating at a small fraction of the rated capacity most of the time; (3) plants designed to bypass the peak flow would also bypass a short duration slug of acid water which would kill the microscopic flora and fauna as well as some larger species of water life; (4) the acid and iron in the stream are not the source of the problem and treatment. would be required as long as the source continues to exist; (5) treatment is extremely expensive from a first-cost standpoint as well as from an operating expense standpoint.

In deep mines the most successful method of source abatement is flooding by sealing all openings which will let water out below the highest portion of the workings. Oxygen is prohibited contact with the coal and sulfates, except for dissolved oxygen in the water. This method is generally only partially successful because adequate seals at all seepage points are difficult to obtain. However, no better alternative has been developed to date. The advantages of flooding deep mines are the long-term costs and benefits. The disadvantages is the lack of assurance that it will work in a given situation. Changes in the movement of ground waters which are difficult or impossible to predict may allow the acid formation and transport processes to continue within the mined area. Due to the inability to document any significant contribution from abandoned deep mines within this watershed, no recommendations for deep mine seals have been included.

The basic approach, for source abatement, on strip mined areas is regrading and revegetation, combined with good water management practices. Factors which affect the formation and transport of pollution are rainfall intensity, duration and frequence; the erodibility of the material; the steepness and length of slope; and the condition of the surface. The rainfall is unchangeable. The soil factors can be altered using fertilizers. The steepness, length of slope and the condition of the surface can be changed by regrading and revegetation.

Abatement measures that appear to be applicable in the Licking Creek Watershed are reviewed starting with the simplest schemes. These include the following: (1) control and alteration of drainage through the diversion of surface water, regrading and other methods; (2) reduction of water in contact with spoil banks through revegetation, increased interception and evapotranspiration losses of soil moisture; (3) neutralization of mine drainage through the use of limestone and vegetation; and (4) reduction of groundwater passing through highwalls with the use of clay barriers. Modifications in mining methods should be reviewed as a means of reducing pollution from active and future strip mines.

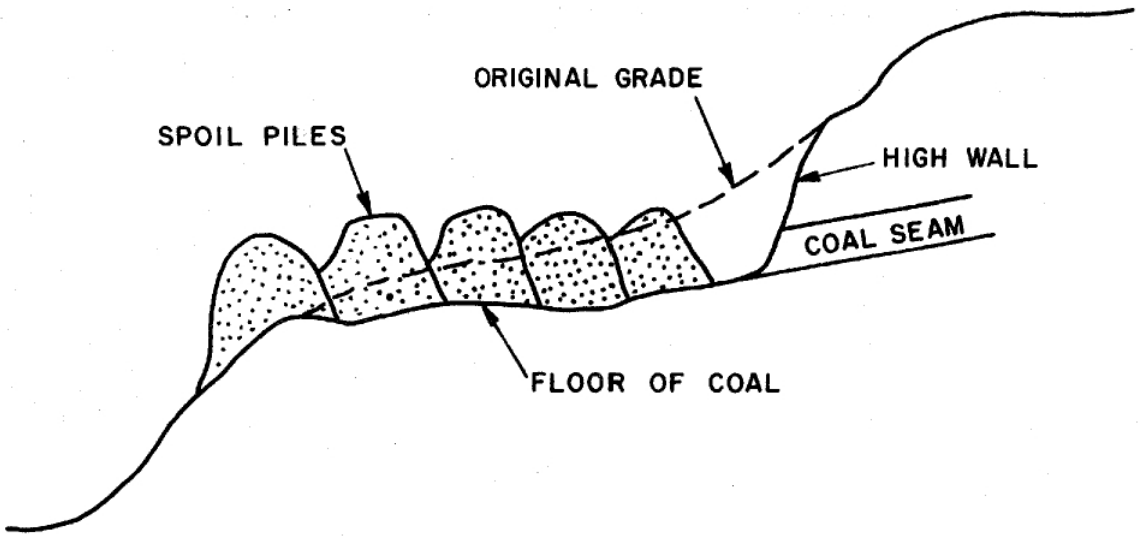
Because of the diffuse and widespread nature of the pollution problems observed in the Licking Creek Watershed, a combination of one or more abatement techniques may be required to significantly reduce the pollution load resulting from abandoned strip and deep mines. Mine drainage is widely scattered in its occurrence, has altered the quality of numerous tributaries to Licking Creek, and has affected water quality in shallow, intermediate and, most probably, deep groundwater flow systems that involve Licking Creek and adjacent watersheds. For these reasons, it will not be possible to abate drainage from several major discharge areas to resolve a significant portion of the total pollution load as had been possible for some watersheds. The volume of mine drainage produced must be reduced wherever possible on a "piecemeal" basis, using a variety of techniques where they best apply.

The hydrogeological and geochemical setting should be understood for the region where an abatement procedure is to be adopted to assure that it will have the intended benefits. Also, areas must be selected for treatment when the maximum benefits can be achieved for the least cost. As the abatement measures become increasingly complex, normally they will increase in cost.

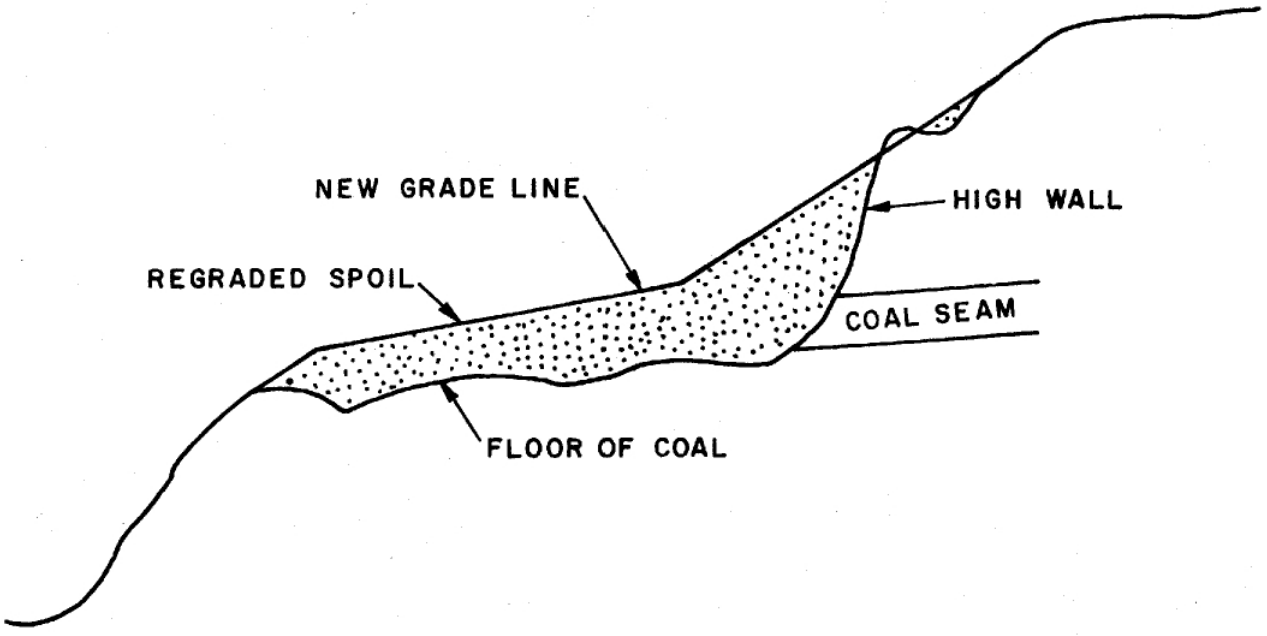
Grading

The regrading of mine spoil to control runoff of precipitation has long been practiced in the mining regions of Pennsylvania. Since the infiltration of spoil material with precipitation is one of the primary problems in acid mine drainage production, the regrading of spoil areas in the Licking Creek Watershed assumes a high priority. The topography of the mine spoil areas is generally of three types or a combination of the three.

Type 1 topography (Figure 7-1) is a floor area of the coal floor surmounted by conical piles of mine spoil resting on the coal floor. This coal floor is usually a layer of impermeable fire clay. The precipitation infiltrates the spoil material and is collected by this fire clay layer and begins to assume lateral movement. The infiltration is facilitated by depressions or bowls formed at the intersection of the spoil piles. The precipitation collects in these depressions and is held there to saturate the underlying spoil, forming acid water, and eventually polluting nearby streams by lateral flow across the



TYPICAL CONDITION BEFORE GRADING



TYPICAL CONDITION AFTER REGRADING

TYPE I TOPOGRAPHY

FIGURE 7-1

fire clay coal floor. Regrading these areas would eliminate the water-retaining depressions and produce a surface contour which would promote runoff of rainwater rather than retention.

The condition described above is the worst of the three types and the most expensive as far as grading is concerned. Without mapping to a scale such as would lend itself to quantity calculation, it is very difficult to estimate a cost for regrading these areas; however, by making certain field observations and using United States Geological Survey mapping, it is possible to prepare a rough estimate. The average end area method was chosen for the grading estimate.

Type 2 topography (Figure 7-2) is the condition in which the floor of the coal is covered by an undulating layer of spoil which consists of low mounds of spoil with shallow depressions between the mounds. The same type of acid formation and transport mechanism is taking place here that occurs in the area of Type 1 topography except it is much less severe. Due to the shallow depressions and low mounds, regrading of Type 2 topography is of moderate expense. Once again the average end area method was chosen for the grading estimate.

Type 3 topography (Figure 7-3) refers to those areas which have been previously restored according to the strip mine reclamation laws.

The major problem in this type of topography is the occurrence of shallow dishshaped recharge depressions. Once again the average end area method was chosen for the grading estimate.

In the above estimates no grading for covering exposed highwalls has been considered.

The grading costs were calculated as follows:

Type 1, 2 & 3	$4,500 per acre
High Wall Sealing	$2.04 per square yard

Connector Wells to Control Potable Groundwater

Connector wells or gravitywells (see Parizek, 1971; Parizek and Tarr, 1972; Parizek and Skelly and Loy 1974) can be used to reduce the volume of water that comes into contact with rocks disturbed by mining in several ways. Connector wells have their best potential under favorable conditions in controlling leakage into deep mines, a problem that has not been fully

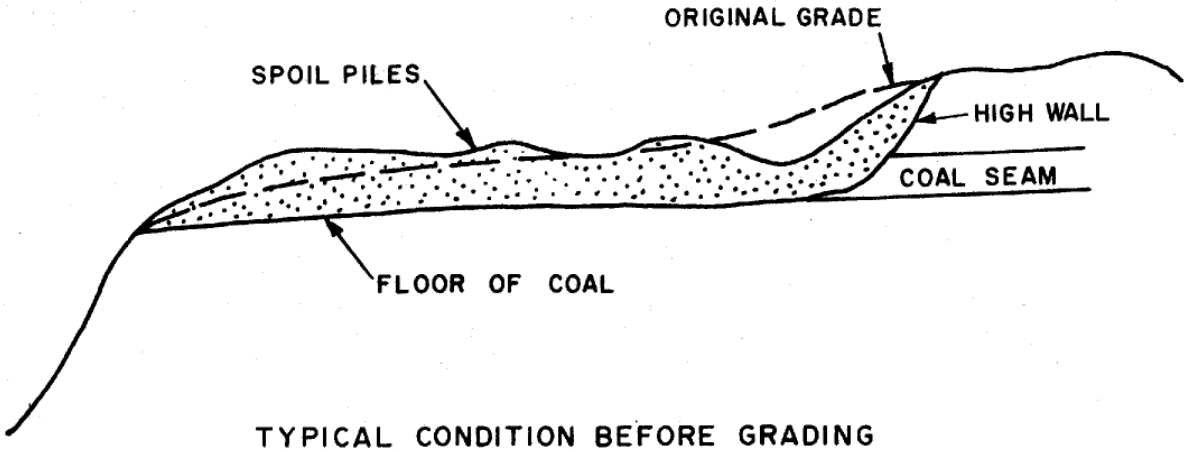
evaluated to date in the Licking Creek Watershed. Alternately they may be used in strip mining regions under restricted conditions to reduce the amount of groundwater that enters strip mine spoil and auger holes from highways, remaining coal, and truncated aquifers. Where strip mines collar hillsides, uplands are still intact and are underlain by productive aquifers that are located above the coal bed. In such cases, connector wells should be beneficial in diverting groundwater from spoil banks before becoming contaminated (Figure 7-4). The connector well concept is predicated on the assumption that a significant reduction in water either entering deep mines or spoil banks will result in a reduction in the volume of mine drainage being produced and a reduction in the total pollution load contained in the drainage. Due to lack of practical experience with this method, no estimate of effectiveness can be made and therefore no further consideration should be given to the method for reclamation purposes in Licking Creek.

Control of Soil Water

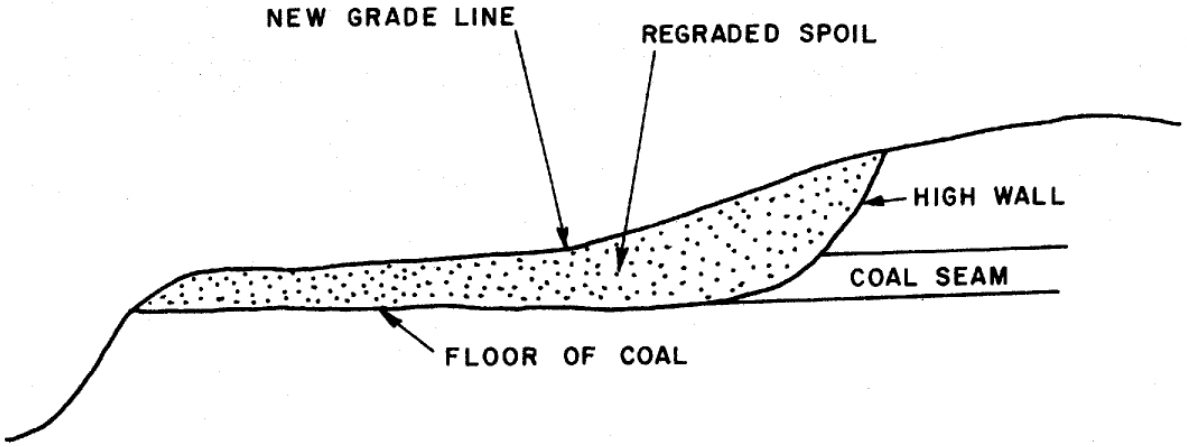
Some of the strip mines in the Licking Creek Watershed have been abandoned for two or more decades, and still spoil banks are only sparsely revegetated. No attempt was made in early mining to replace topsoil or unconsolidated overburden deposits above spoil materials. Rather, these materials were mixed with fragmented shale, siltstone, sandstone and fireclay bedrock in a random manner. Fine-grained matrix material has increased over the years as shale, siltstone and clay blocks have broken up by mechanical weathering, but the soil moisture-holding capacity of these deposits is still very low when compared to the original soil and weather mantle overburden. Spoil banks observed have a high porosity, which favors the rapid infiltration of surface water and maximizes mine drainage formation. The irregular backfill procedure used produces closed surface depressions that favor ponding areas, which greatly increase infiltration to spoil banks.

A regrading program will help to eliminate closed depressions and ponding areas and could help to promote more runoff by overland flow, particularly along steeper slopes. However, the coarse-textured nature of the spoil deposits and their high permeability characteristics will favor rapid internal drainage and groundwater recharge for years to come until a less permeable surface soil is formed.

At present the transpiration losses of soil moisture from abandoned spoil banks is still minor, largely due to the sparse nature of vegetation. Evergreens that survived initial planting are still relatively small and widely scattered in many areas. Their root systems are probably restricted as well. Ground cover between trees is still nonexistent to sparse. The poor survival by vegetation and slow adjustment to the area most likely reflect the acid nature of the spoil banks and their poor moisture-holding capacity.



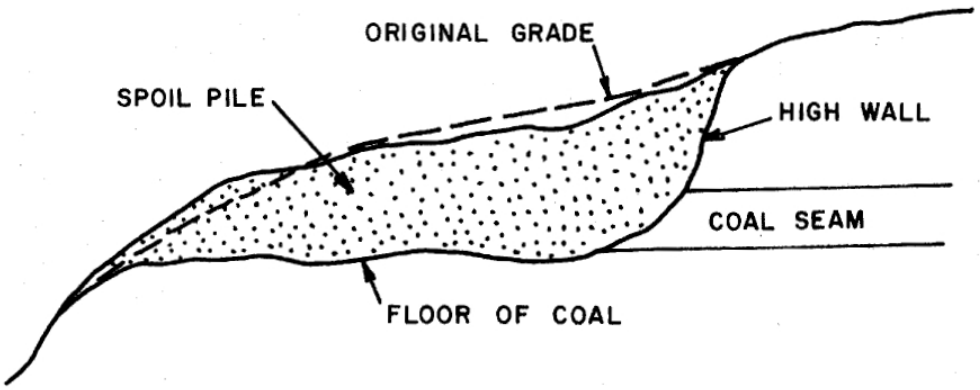
TYPICAL CONDITION BEFORE GRADING



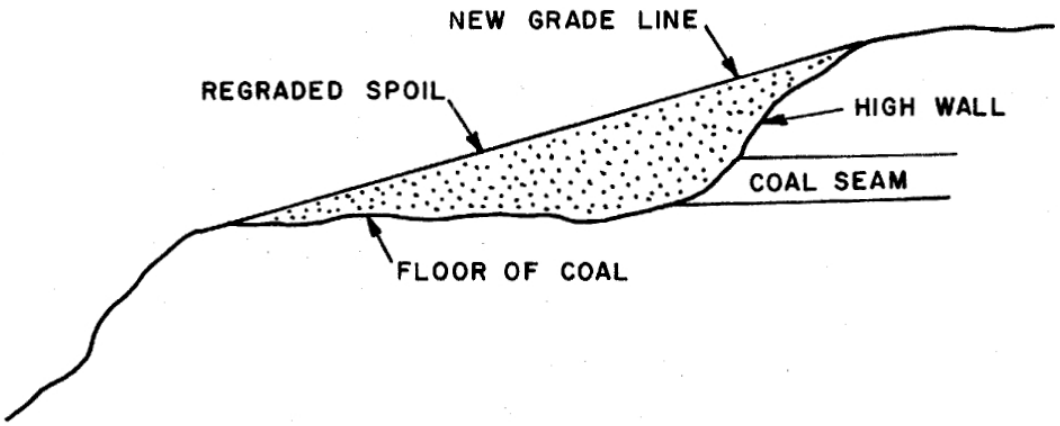
TYPICAL CONDITION AFTER REGRADING

TYPE 2 TOPOGRAPHY

FIGURE 7-2



TYPICAL CONDITION BEFORE GRADING



TYPICAL CONDITION AFTER REGRADING

TYPE 3 TOPOGRAPHY

FIGURE 7-3

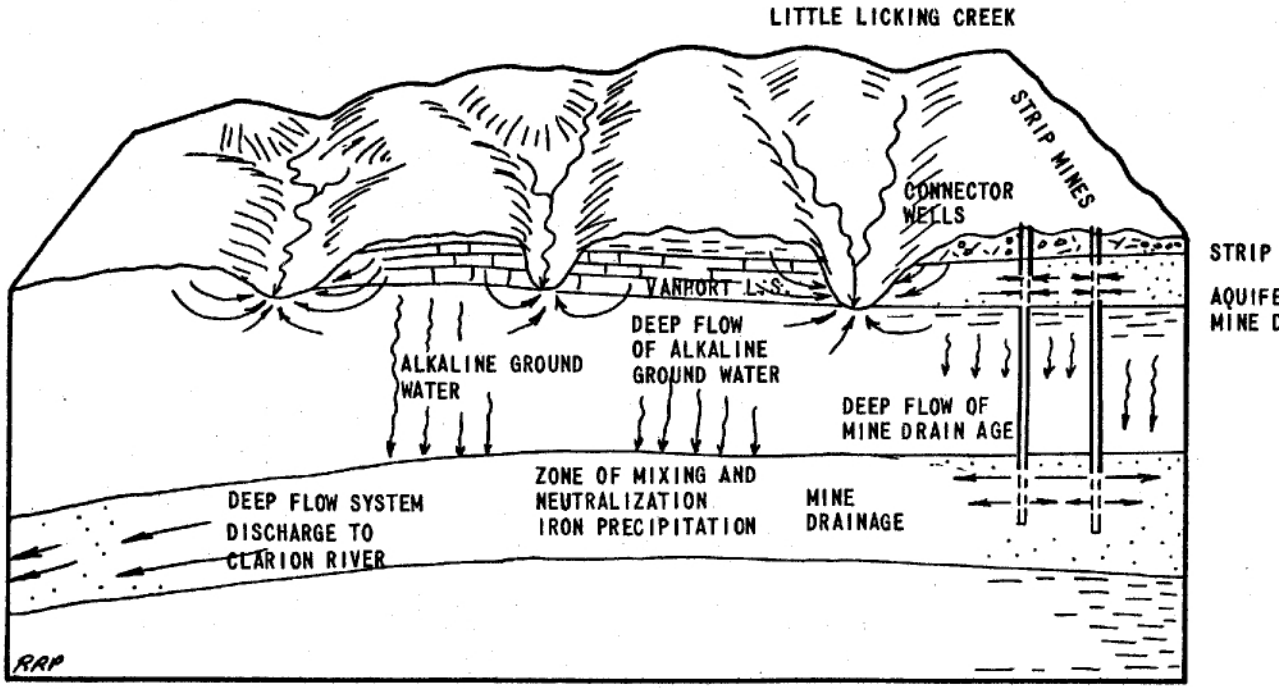


FIGURE 7-4

CONNECTOR WELLS USED TO GRAVITY FEED ACID MINE DRAINAGE TO A DEEP AQUIFER SYSTEM THAT CONTAINS ALKALINE GROUND WATER DOWN GRADIENT. MIXING AND NEUTRALIZATION REACTIONS ARE OCCURRING DISTANT FROM THE GRAVITY WELLS. IRON AND OTHER PRECIPITATES ARE ACCUMULATING WITHIN THE AQUIFER DISTANT FROM THE GRAVITY WELLS.

The evapotranspiration losses of soil moisture have not been measured or calculated for these spoil materials on site, but values are expected to be very low, generally less than 5 to 8 inches per year. Interception and evaporation losses from vegetation are still trivial in most areas and will not increase until the area is revegetated on an extensive basis.

Regrading of abandoned spoil banks will not be sufficient to establish a cover crop of trees or grasses; in fact, it will set some mines back that have started to show signs of revegetation unless other more costly steps are also taken. For example, lime or limestone and fertilizer may be used to recondition the surficial spoil deposits and promote early and rapid growth.

Left onto themselves, 25 to 30 or more years may be required before evapotranspiration losses from spoil banks increase to 10 to 15 inches per year. This rate could be achieved within a two- to three-year period using fertilizer, lime and limestone, and seeding of grass combined with trees. Ultimately the evapotranspiration rate may be increased to 20 to 25 inches of water per year, which should greatly reduce the pollution load derived from the region. However, the residual pollution load at this stage of vegetation should greatly exceed the pre-mining condition for many years to come. Other corrective action will also have to be taken.

Early and rapid revegetation will depend upon a source of nutrients, adjustment of soil, pH, and an adequate soil moisture content to stimulate germination and growth. Commercial fertilizers may be used in conjunction with lime and/or limestone to speed up the growth process. Sewage sludge is an alternate source of nutrients that combines both organic matter and moisture if used in the liquid form. The results of demonstration studies at the Pennsylvania State University reveal that repeated applications of sewage sludge over at least one growing season will greatly stimulate plant growth including grasses, evergreens and deciduous trees. A single 2-inch application had a beneficial result in promoting growth on bare spoil materials, but survival was not as great as for cases where repeated applications were used.

Some improvements in water quality should be expected from the sewage sludge alone when applied to regraded spoil banks; however, the main impact of using sewage sludge either in liquid or dried form will result from the increased plant responses that are achieved and the increased evapotranspiration losses of soil moisture that occur. Other additives, namely limestone, should be considered to bring about maximum beneficial results in abating pollution from strip mine spoils.

Revegetation

Land is a limited natural resource which is too valuable to lie barren only to be eroded away. The establishment of a plant community on the soil would increase the returns from the land as well as eliminate it as an aesthetic eyesore. The main purpose of revegetation would be to serve as a method of acid mine drainage abatement. The vegetation would serve as a means of interception of water prior to its use in the formation of acid mine drainage. Other benefits of the vegetation would be wildlife food and cover, soil stabilization, timber production, Christmas tree production and recreational uses.

The factors and features of the spoil material must be considered in any revegetation plan as they may limit plant growth, land use, and machinery operations. The three major factors which may place limitations on revegetation are acidity, stoniness, and slope. Spoils which have a pH below 4.5 or a slope of more than 25 percent are not suited for agricultural use. Due to the location and nature of this land, it is proposed that the land be revegetated for the multiple uses. of agriculture, low-density recreation, woodland and wildlife.

Regrading, as was discussed previously, will be one of the prerequisite site preparations. Agricultural lime will have to be added in order to raise the pH to an acceptable level. Lime applications of four tons per acre have been experienced depending on the pH of the soil prior to planting. A tooth-bladed grader could assist in working the lime into the upper level of the spoil wherever possible. Scarification of the soil surface is felt to aid in preventing surface runoff and hastening the establishment of vegetative cover. Compaction is also broken up and thus seed germination and rooting are enhanced by scarification. The addition of fertilizer to the spoil would increase the rate of survival and establishment. A formula of 15-15-15 is often used with quantities of N, $P20_5$, and K20 reaching 40 pounds per acre each.

The application of mulch will aid the revegetation efforts in many ways. Mulching aids in soil stabilization and prevention of erosion. A mulch may add nutrients to the soil after giving the germinating seeds a chance to establish themselves before it decomposes.

Seeding is recommended for grasses and legumes, whereas planting yields better establishment for shrubs and trees. Some direct seeding of black locust and arnot bristly locust has proven successful when the spoil has been heavily fertilized with N and P_20_5 before seeding. Recommendations for seeding grasses and legumes are presented in A Guide for Revegetating Bituminous Strip Mine Spoils in Pennsylvania.

* Penna. Dept. of Environmental Resources

When planting for wildlife, woodland and non-developed recreation, a variety of vegetative covers should be utilized. Wildlife prefer small openings, five to ten acres, planted with grasses or legumes. Irregular shapes increase the edge effect, which is the most utilized portion of the area. Shrub species provide fruits and browse for the wildlife. Conifers are beneficial since they provide year-round cover. Hardwoods provide fruits, nuts and seeds which are readily consumed by small mammals and birds. Species diversity and habitat variation are the primary goals in establishing wildlife cover.

Areas which are reclaimed with an orientation toward production should be those which have little slope and are easily accessible. A more homogeneous stand is preferred so that even growth and harvest age may be attained. Conifers are often preferred since a majority of the spoils fall within their best acidity range, a pH of 4.0 to 6.0. Conifers provide year-round cover which, as mentioned, is desirable for wildlife and also is favored for aesthetic purposes. At present there is a shortage of softwood timber and thus a market for it. A mixture of types should be planted so that survival chances are enhanced.

Hardwood and conifers require planting since very little success has been experienced with direct seeding. Due to the expense of planting seedlings, care must be taken in the selection of the right species and stock for the site. The Revegetation Guide recommends the use of the following species where 50 percent or more of the spoil areas are below a pH of 4.5 but not more than 50 percent are below a pH of 4.0:

TABLE 7-1

GRASSES	LEGUMES	TREES	SHRUBS
Tall oatgrass (4.5)	Lespedeza service*	Austrian pine* (3.5)	Autumn Olive* (3.5)
Fall fescue		Jack Pine	Lespedeza bicolor
Redtop (4.5)		Pitch pine* (3.5)	Mugho pine* (3.5)
Weeping lovegrass (4.0)		Red pine* (3.5)	Arnot bristly locust (3.5)
		Scotch pine	
		White pine	
		Japanese larch	
		Black locust* (3.5)	
		Red oak	
		European alder*	
		Black alder (3.5)	
		European white birch	

* May be utilized on spoil areas where more than 50 percent of the area is below a pH of 4.0. The number represents the limit of acidity that species will tolerate.

Other species which may be planted on spoil when the pH is more neutral are listed below:

TABLE 7-2

GRASSES	LEGUMES	TREES
Timothy	Birdsfoot trevoil (5.0)	Hybird poplar
Switchgrass		
Reed canarygrass	Crownvetch (4.5)	
Rye grass		

More data must be collected on analysis of the spoil materials and their acidity before a preliminary revegetation plan can be developed. It is recommended that the primary orientation in revegetation be to establish a relatively quick cover of a permanent nature. The cover shall be beneficial to wildlife and have some future timber potential on accessible areas. The vegetative types should be in small stands with beneficial clearings planted in grasses or legumes. The undeveloped recreation would be hunting, hiking, and cycle-snowmobile trails. If a vegetative cover is established with these uses in mind and the restrictions of the soil type, the land has the potential to be brought back to the usable category at the same time as alleviating the acid mine drainage problem.

Reducing Ground Water Influx at Highwalls

Clay Barrier

Pollution caused by the passage of ground water through pollution-forming materials can be eliminated or greatly reduced by using clay barriers where low water pressure is expected. The highwall is first cleaned of loose rock and debris. Clay is then compacted along the face of the highwall. A good quality plastic clay should be used to ensure impermeability and to enable it to flow into cracks and voids along the wall. The area around and over the clay barrier should be backfilled and compacted to prevent the clay from flowing under pressure. Under ideal conditions clay barriers may be capable of withstanding approximately 30 feet of head. (See Figure 7-5)

Grout Curtain

During surface mining operations the rock overburden is fractured, increasing the permeability behind the highwall. Grout Curtains are effective in reducing the permeability of this rock. Boreholes are placed parallel to the highwall at ten-foot centers and pressure injected. Pressure forces the grout down the borehole and into the fractured zone filling the voids. As the grout hardens in the voids of the fractured zone, permeability is decreased. The efficiency of the grout curtain may be increased if zones are grouted separately instead of grouting the entire borehole at one time. Large voids encountered during drilling should be filled with aggregate since grouting is effective only where voids are small. (See Figure 7-6)

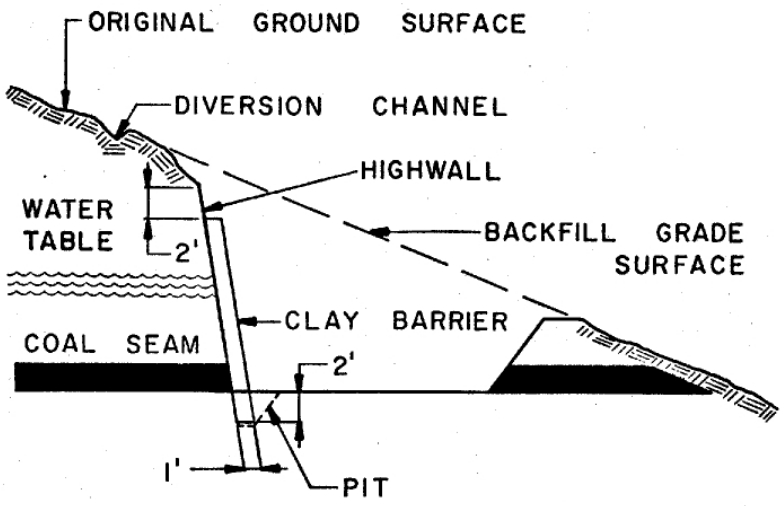


FIGURE 7-5 CLAY BARRIER

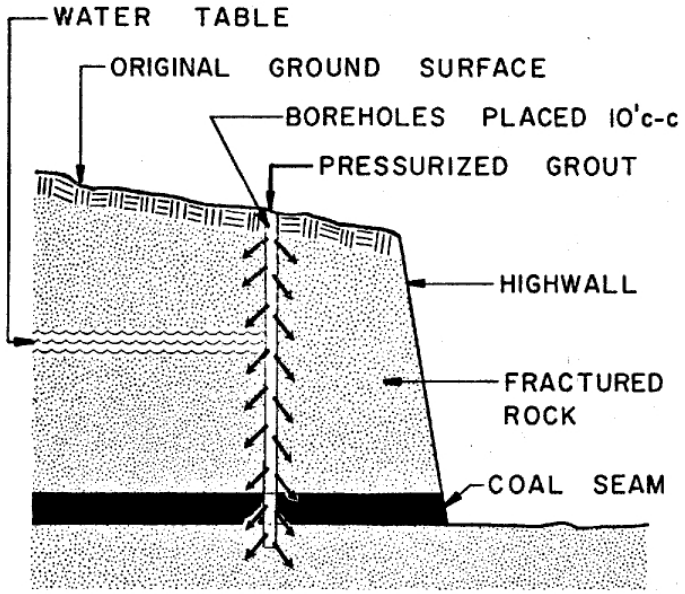


FIGURE 7-6 GROUT CURTAIN

Specific Abatement Recommendations*

Of the several abatement methods considered, two have emerged as the most desirable from the standpoint of effectiveness and cost. Certain other methods are undesirable and have been removed from consideration due to ineffectiveness, high cost, and the absence of satisfactory prior experience. The two methods recommended for use in abatement are as follows:

Type 1: Regrading, liming, fertilizing and planting to restore not only aesthetically but to abate further pollution due to percolation of precipitation through the acid-producing spoil or refuse material.

Regrading should be so as to permit a gradual overland drainage of surface water with velocities which would preclude erosion of the surface. Slopes of between 3 and 15 degrees would meet these requirements. There are areas which require slopes steeper than 15 degrees and erosion protection in the form of hay mulch.

Lime application should be in the form of ground dolomitic agricultural limestone. Rates of application will of course be dependent upon results of spoil acidity analysis at thetime of design; however, for estimating purposes an application rate of four tons per acre is assumed. Planting is anticipated as grass cover, the actual decision being deferred until design of the specific projects. For purposes of estimating, a mixture of equal parts of Tall Oatgrass and Tall Fescue applied at a rate of 22 pounds per acre is assumed.

Fertilization should be with a chemical fertilizer having a formula of 15-15-15 and applied at a rate of 250 pounds per acre.

Type 2: Construction of a clay barrier to prevent lateral transfer of ground water into the area of mine spoil and eventually into the area streams as a contribution to the pollution load. Such a barrier should be constructed from 2.0 feet below the floor of the mine to a point 2'0" from the top of the highwall. The barrier should be composed of a good quality plastic clay and should be a minimum of 1.0 foot in thickness.

* All references to pollution production refer to acid loadings.

Specific Areas

Area G

This area is mine spoil covering approximately 61 acres. The area appears to have been previously restored subsequent to mining. There are shallow dish-shaped depressions present which could act as ground water recharges. No highwalls are present. Location is along the western edge of L. R. 16031, 0.3 miles north of State Route #368. The area ix tributary to stream #1-08 (Anderson Run) and contributes approximately 83% of the total pollution of Anderson Run (1,212 pounds per day of acid and 12,097 pounds per day of sulfate) and approximately 9% of the total pollution present at the mouth of Licking Creek.

Reclamation will involve the movement of 84,790 cubic yards of spoil and the planting of 61 acres. Some perimeter areas along the southern and southwestern edges have vegetative cover at present and should not be disturbed. Costs are ax follows:

Grading 61 acres @ $4,500	=	$274,500.00
Planting 61 acres @ $484.00	=	29,524.00
Total	=	$304,024.00

Individuals in the area have reported the existence of a flowing well beneath the spoil in Area G.

Area H

This area is mine spoil covering approximately 31 acres. The area has been restored subsequent to mining and has depressions which could act ax ground water recharges. No highwalls are present. Location is along the eastern edge of L. R. 16031, 0.3 miles north of State Route #368. This area ix tributary to stream #1-10 (Mineral Run) and contributes approximately 11% of the total pollution of Mineral Run (612 pounds of acid per day and 2,183 pounds of sulfate per day) and approximately 4% of the total pollution present at the mouth of Licking Creek.

Reclamation will involve the movement of 43,090 cubic yards of spoil and the planting of 31 acres. Costs are ax follows:

Grading 31 acres @ $4,500	=	$139,500
Planting 31 acres @ $484.00	=	15,004
Total	=	$139,984

Area I

This area is mine spoil covering approximately 194 acres. This area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. Approximately 185.5 lineal feet of highwall are present. The area is tributary to Stream #1-10 (Mineral Run) and contributes approximately 67% of the total pollution to Mineral Run (3,830 pounds of acid per day and 13,657 pounds of sulfate per day) and approximately 27% of the total pollution present at the mouth of Licking Creek. Spoil area I is located east of Mineral Run and north of Sligo Borough.

Reclamation will involve the management of 269,660 cubic yards of spoil, the planting of 194 acres, and the sealing of 1,855 lineal feet of high wall to a height of approximately 25 feet. Costs are as follows:

Grading 194 acres @ $4,500	=	$873,000.00
Planting 194 acres @ $484.00	=	93,896.00
Highwall sealing 5,153 s.y. @ $2.04	=	10,512.00
Total	=	$977,408.00

Area MM

This area is mine spoil covering approximately 18 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. The area is tributary to Stream #1-10 (Mineral Run) and contributes approximately 6% of the total pollution to Mineral Run (351 pounds of acid per day and 1,251 pounds of sulfate per day) and approximately 2% of the total pollution present at the mouth of Licking Creek. Spoil MM is located northeast of Sligo Borough.

Reclamation will involve the movement of 25,020 cubic yards of spoil and the planting of 18 acres. Costs are as follows:

Grading 18 acres @ $4,500	=	$81,000.00
Planting 18 acres @ $484.00	=	8,712.00
Total	=	$89,712.00

Area QQ

This area is mine spoil covering approximately 32 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. No highwalls are present. The area is tributary to Stream #110 (Mineral Run) and contributes approximately 11% of the total pollution to Mineral Run (640 pounds of acid per day and 2,282 pounds of sulfate per day) and approximately 5% of the total pollution present at the mouth of Licking Creek. Spoil Area QQ is located east of State Route #368 and south of Township Road 435.

Reclamation will involve the movement of 134,192 cubic yards of spoil and the planting of 32' acres. Costs are as follows:

Grading 32 acres @ $4,500	=	$144,000.00
Planting 32 acres @ $484	=	15,488.00
Total	=	$159,488.00

Area RR

This area is mine spoil covering approximately 20 acres. The area has been restored subsequent to mining and has depressions which could act as ground water recharges. The area is tributary to Stream #1-11 (Little Licking Creek) and contributes approximately 3% of the total pollution to Little Licking Creek (164 pounds of acid per day and 1,374 pounds of sulfate per day) and approximately 1% of the total pollution present at the mouth of Licking Creek. Spoil Area RR is located east of Route 68, 0.4 miles north of L. R. 16021.

Reclamation will involve the movement of 27,800 cubic yards of spoil and the planting of 20 acres. Costs are as follows:

Grading 20 acres @ $4,500	=	$90,000.00
Planting 20 acres @ $484.00	=	9,680.00
Total	=	$99,680.00

Area SS

This area is mine spoil covering. approximately 123 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. Approximately 4,050 lineal feet of highwall are present. The area is tributary to Stream #1-11 (Little Licking Creek). It contributes approximately 21% of the. total pollution to Little Licking Creek (1,025 pounds of acid per day and 86.4 pounds of sulfate per day) and approximately 7% of the total pollution present at the mouth of Licking Creek. Spoil Area SS is located between L. R. 16099 and Township Road 451 near the southwestern boundary of Sligo Borough.

Reclamation will involve the movement of 170,970 cubic yards of spoil, the planting of 123 acres, and the sealing of 4,050 lineal feet of high wall to a height of approximately 25 feet Costs are as follows:

Grading 123 acres @ $4,500	=	$553,500.00
Planting 123 acres @ $484.00	=	59,532.00
Highwall sealing 11,250 s.y. @ $2.04	=	22,950.00
Tota	l=	$635,982.00

Area ZB

This area is mine spoil covering approximately 102 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. Approximately 2,054 lineal feet of highwall are present. The area is tributary to Stream #1-11 (Little Licking Creek) and contributes approximately 17% of the total pollution to Little Licking Creek (852 pounds of acid per day and 7,164 pounds of sulfate per day) and approximately 6% of the total pollution present at the mouth of Licking Creek. Spoil Area ZB is located at the headwaters of Little Licking Creek.

Reclamation will involve the movement of 777,762 cubic yards of spoil, the planting of 102 acres, and the sealing of 2,054 lineal feet of highwall to a height of approximately 25 feet. Costs are as follows:

Grading 102 acres @ $4,500	=	$459,000.00
Planting 102 acres @ $484.00	=	49,368.00
Highwall sealing 5,706 s.y. @ $2.04	=	11,640.00
Total	=	$520,008.00

Area ZA

This area is mine spoil covering approximately 107 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. Approximately 5,646 lineal feet of highwall are present. The area is tributary to Stream #1-01-14 (unnamed tributary) and contributes approximately 35% of the total pollution to 1-01-14 (1,442 pounds of acid per day and 5,697 pounds of sulfate per day) and approximately 10% of the total pollution present at the mouth of Licking Creek. Spoil Area ZA is located 0.1 miles north of the intersection of L. R. 16021 and Township Road 452.

Reclamation will involve the movement of 148,730 cubic yards of spoil, the planting of 107 acres, and the sealing of 5,646 lineal feet of high wall to a height of approximately 22 feet. Costs are as follows:

Grading 107 acres @ $4,500	=	$481,500.00
Planting 107 acres @ $484.00	=	51,788.00
Highwall sealing 15,684 s.y. @ $2.04	=	31,995.00
Total	=	$565,283.00

Area AA

This area is mine spoil covering approximately 22 acres. The area has low mounds of spoil with depressions between the mounds. No highwalls are present. The area is tributary to Stream #1-01-14 (unnamed tributary) and contributes approximately 7% of the total pollution to 1-04-14 (293 pounds of acid per day and 1,159 pounds of sulfate per day) and approximately 2% of the total pollution present at the mouth of Licking Creek. Spoil Area AA is located north of the intersection of L. R. 16021 and Township Road 452 and south of Spoil Area ZA.

Reclamation will involve the movement of 30,580 cubic yards of spoil and the planting of 22 acres. Costs are as follows:

Grading 22 acres @ $4,500	=	$ 99,000.00
Planting 22 acres @ $484.00	=	10,648.00
Total	=	$109,648.00

Area BB

This area is mine spoil covering approximately 28 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. Approximately 2,850 lineal feet of highwall are present. The area is tributary to Stream #1-01-14 (unnamed tributary) and contributes approximately 9% of the total pollution to 1-01-14 (378 pounds of acid per day and 1,493 pounds of sulfate per day) and approximately 3% of the total pollution present at the mouth of Licking Creek. Spoil Area BB is located east of L. R. 16013 and south of L. R. 16021.

Reclamation will involve the movement of 38,920 cubic yards of spoil, the planting of 28 acres and the sealing of 2,850 lineal feet at highwall to a height of approximately 25 feet. Costs are as follows:

Grading 28 acres @ $4,500	=	$126,000.00
Planting 28 acres @ $484.00	=	13,552.00
Highwall sealing 7,917 s.y. @ $2.04	=	16,151.00
Total	=	$155,703.00

Area CC

This area is mine spoil covering approximately 19 acres. The area has low mounds of spoil with depressions between the mounds. Approximately 2,475 lineal feet of highwall are present. The area is tributary to Stream #1-01-14 (unnamed tributary) and contributes approximately 6% of the total pollution to 1-01-14 (252 pounds of acid per day and 997 pounds of sulfate per day) and approximately 2% of the total pollution present at the mouth of Licking Creek. Spoil Area CC is located north of L. R. 16021 and west of Township Road 376.

Reclamation will involve the movement of 26,410 cubic yards of spoil, the planting of 19 acres and the sealing of 2,475 lineal feet of highwall to a height of approximately 25 feet. Costs are as follows:

Grading 19 acres @ $4,500	=	$ 85,500.00
Planting 19 acres @ $484.00	=	9,196.00
Highwall sealing 6,875 s.y. @ $2.04	=	14,025.00
Total	=	$108,721.00

Area LL

This area is mine spoil covering approximately 105 acres. The area has low mounds of spoil with depressions between the mounds. Approximately 5,055 lineal feet of highwall are present. The area is tributary to Stream #1-04-14 (unnamed tributary) and contributes approximately 34% of the total pollution to 1-01-14 (1,413 pounds of acid per day and 5,583 pounds of sulfate per day) and approximately 10% of. the total pollution present at the mouth of Licking Creek. Spoil area LL is located east of the Sligo Branch, Pennsylvania Railroad, south of L. R. 16021, and west of Township Road 452.

Reclamation will involve the movement of 145,950 cubic yards of spoil, the planting of 105 acres, and the sealing of 5,055 lineal feet of highwall to a height of approximately 25 feet. Costs are as follows:

Grading 105 acres @ $4,500	=	$472,500.00
Planting 105 acres @ $484.00	=	50,820.00
Highwall sealing 14,042 s.f. @ $2.04	=	28,646.00
Total	=	$551,966.00

Area b

This area is mine spoil refuse covering approximately 7 acres. The area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. No highwalls are present. The area is tributary to Stream #1-01-14 (unnnamed tributary) and contributes approximately 2.5% of the total pollution to 1-01-14 (101 pounds of acid per day and 397 pounds of sulfate per day) and approximately 1% of the total pollution present at the mouth of Licking Creek. Refuse Area b is located north of the intersection of L.R. 16021 and Township Road 452 and south of Spoil Area ZA.

Reclamation will involve the movement of 9,730 cubic yards of refuse and the planting of 7 acres. Costs are as follows:

Grading 7 acres @ $4,500	=	$31,500.00
Planting 7 acres @ $484.00	=	3,388.00
Total	=	$34,888.00

Area g

This area is mine spoil refuse covering approximately 16 acres. The area has low mounds of spoil with depressions between the mounds. No highwalls are present. The area is tributary to Stream #1-01-14 (unnamed tributary) and contributes approximately 5% of the total pollution to 1-01-14 (210 pounds of acid per day and 828 pounds of sulfate per day) and approximately 1.5% of the total pollution present at the mouth of Licking Creek. Refuse Area g is located east of the Sligo Branch, Pennsylvania Railroad, south of L.R. 16021, and west of Township Road 452.

Reclamation will involve the movement of 57,128 cubic yards of refuse and the planting of 16 acres. Costs are as follows:

Grading 16 acres @ $4,500	=	$72,000.00
Planting 16 acres @ $484.00	=	7,744.00
Total	=	$79,744.00

AREA A

This area is spoil covering approximately 24 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01, 1-01-01 and contributes approximately (73 pounds of acid per day and 3192 pounds of sulfate per day) and approximately .52% of the total pollution present at the mouth of Licking Creek.

Location is 1.3 miles south of Callensburg along T368.

Reclamation will involve the movement of 33,360 c. y. of spoil and the planting of 24 acres.

Costs are as follows:

Grading 24 acres @ $4,500	=	$108,000.00
Planting 24 acres @ $484	=	11,616.00
Total	=	$119,616.00

AREA B.

This area is spoil covering approximately 86 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1, 1-01 and contributes approximately (148 pounds of acid per day and 2,999 pounds of sulfate per day) and approximately 1.13% of the total pollution present at the mouth of Licking Creek.

Location is 1.1 mile south of Callensburg along 16019.

Reclamation will involve the movement of 119,540 c.y. of spoil and the planting of 86 acres.

Costs are as follows:

Grading 86 acres @ $4,500	=	$387,000.00
Planting 86 acres @ $484	=	41,624.00
Total	=	$428,624.00

AREA C

This area is spoil covering approximately 17 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-03 and contributes approximately 100% of the total pollution of stream 1-03 (19 pounds of acid per day and 244 pounds of sulfate per day) and approximately .13% of the total pollution present at the mouth of Licking Creek.

Location is 1.9 miles southeast of Callensburg along T362.

Reclamation will involve the movement of 23,630 c.y. of spoil and the planting of 17 acres.

Costs are as follows:

Grading 17 acres @ $4,500	=	$76,500.00
Planting 17 acres @ $484	=	8,228.00
Total	=	$84,728.00

AREA D

This area is spoil covering approximately 4 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1 and contributes approximately (7 pounds of acid per day and 128 pounds of sulfate per day) and approximately 0.05% of the total pollution present at the mouth of Licking Creek.

Location is 1.7 miles east of Callensburg along 368.

Reclamation will involve the movement of 37,418 c.y. of spoil and the planting of 4 acres.

Costs are as follows:

Grading 4 acres @ $4,500.00	=	$18,000.00
Planting 4 acres @ $484	=	1,936.00
Total	=	$19,936.00

AREA E

This area is spoil covering approximately 68 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-05, 1-07, 1 and contributes approximately (162 pounds of acid per day and 3498 pounds of sulfate per day) and approximately 1.1% of the total pollution present at the mouth of Licking Creek.

Location is 0.7 miles north of Mt. Airy along T374.

Reclamation will involve the movement of 94,520 c.y. of spoil and the planting of 68 acres.

Costs are as follows:

Grading 68 acres @ $4,500	=	$306,000.00
Planting 68 acres @ $484	=	32,912.00
Total	=	$338,912.00

AREA F

This area is spoil covering approximately 101 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-07 and contributes approximately .82% of the total pollution of stream 1-07 (145 pounds of acid per day and 2,671 pounds of sulfate per day) and approximately 1.03% of the total pollution present at the mouth of Licking Creek.

Location is 0.7 miles north of Mt. Airy along T374.

Reclamation will involve the movement of 479,302 c.y. of spoil and the planting of 101 acres.

Costs are as follows:

Grading 101 acres @ $4,500	=	$454,500.00
Planting 101 acres @ $484	=	48,884.00
Total	=	$503,384.00

AREA J

This area is spoil covering approximately 47 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-12, 1 and contributes approximately (248 pounds of acid per day and 1,252 pounds of sulfate per day) and approximately 1.8% of the total pollution present at the mouth of Licking Creek.

Location is 0.4 miles northeast of Sligo along 68.

Reclamation will involve the movement of 568,714 c.y. of spoil and the planting of 47 acres.

Costs are as follows:

Grading 47 acres @ $4,500	=	$211,500.00
Planting 47 acres @ $484	=	22,748.00
Total	=	$234,248.00

AREA K

This area is spoil covering approximately 79 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-14, 1-16 and contributes approximately (82 pounds of acid per day and 599 pounds of sulfate per day) and approximately .58% of the total pollution present at the mouth of Licking Creek.

Location is 1.1 mile east of Sligo along T246.

Reclamation will involve the movement of 344,058 c.y. of spoil and the planting of 79 acres.

Costs are as follows:

Grading 79 acres @ $4,500	=	$355,500.00
Planting 79 acres @ $484	=	38,236.00
Total	=	$393,736.00

AREA L

This area is spoil covering approximately 14 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-10 and contributes approximately 4.8% of the total pollution of stream 1-10 (14 pounds of acid per day and 782 pounds of sulfate per day) and approximately 0.1% of the total pollution present at the mouth of Licking Creek.

Location is 1.8 miles northeast of Sligo along T426.

Reclamation will involve the movement of 19,460 c.y. of spoil and the planting of 14 acres.

Costs are as follows:

Grading 14 acres @ $4,500	=	$63,000.00
Planting 14 acres @ $484	=	6,776.00
Total	=	$69,776.00

AREA M

This area is mine spoil refuse covering approximately 2 acres. This area has conical piles of spoil overlaying a clay base with depressions located at the intersection of the piles. No highwalls are present. The area is tributary to Stream 1-08 and contributes approximately 2.5% of the total pollution to Stream 1-08 (36 pounds of acid per day and 366 pounds of sulfate per day) and approximately 0.3% of the total pollution present at the mouth of Licking Creek.

Reclamation will involve the movement of 2,780 c.y. of spoil refuse and the planting of 2 acres.

Costs are as follows:

Grading 2 acres @ $4,500	=	$9,000.00
Planting 2 acres @ $484	=	$968.00
Total	=	$9,968.00

AREA N

This area is spoil covering approximately 10 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-08 and contributes approximately 13.6% of the total pollution of stream 1-08 (199 pounds of acid per day and 1,989 pounds of sulfate per day) and approximately 1.4% of the total pollution present at the mouth of Licking Creek.

Location is 3.7 miles northeast of Sligo along 854.

Reclamation will involve the movement of 13,900 c.y. of spoil and the planting of 10 acres.

Costs are as follows:

Grading 10 acres @ $4,500	=	$45,000.00
Planting 10 acres @ $484	=	4,840.00
Total	=	$49,840.00

AREA 0

This area is spoil covering approximately 5 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-18 and contributes approximately 2.9% of the total pollution of stream 1-18 (7 pounds of acid per day and 156 pounds of sulfate per day) and approximately .05% of the total pollution present at the mouth of Licking Creek.

Location is 3 miles northeast of Sligo along T432.

Reclamation will involve the movement of 6,950 c.y. of spoil and the planting of 5 acres.

Costs are as follows:

Grading 5 acres @ $4,500	=	$22,500.00
Planting 5 acres @ $484	=	2,420.00
Total	=	$24,920.00

AREA P

This area is spoil covering approximately 4 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-18 and contributes approximately 2.29% of the total pollution of stream 1-18 (6 pounds of acid per day and 1,234 pounds of sulfate per day) and approximately .04% of the total pollution present at the mouth of Licking Creek.

Location is 2.9 miles northeast of Sligo along T432.

Reclamation will involve the movement of 5,560 c.y. of spoil and the planting of 4 acres.

Costs are as follows:

Grading 4 acres @ $4,500	=	$18,000.00
Planting 4 acres @ $484	=	1,936.00
Total	=	$19,936.00

AREA Q

This area is spoil covering approximately 6 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-18 and contributes approximately 4.02% of the total pollution of stream 1-18 (10 pounds of acid per day and 216 pounds of sulfate per day) and approximately .07% of the total pollution present at the mouth of Licking Creek.

Location is 2.9 miles northeast of Sligo along T432.

Reclamation will involve the movement of 8,340 c.y. of spoil and the planting of 6 acres.

Costs are as follows:

Grading 6 acres @ $4,500	=	$27,000.00
Planting 6 acres @ $484	=	2,904.00
Total	=	$29,904.00

AREA S

This area is mine spoil covering approximately 177 acres. The area has been restored subsequent to mining and has depressions which could act as ground water recharges. No highwalls are present. The area is tributary to Stream 1-11 (Little Licking Creek) and contributes approximately 7.15% of the total pollution to Little Licking Creek (352 pounds of acid per day and 2,955 pounds of sulfate per day) and approximately 2.5% of the total pollution present at the mouth of Licking Creek.

Location is east of Sligo south of State Route #68.

Reclamation will involve the movement of 246,030 c.y. of spoil refuse and the planting of 177 acres.

Costs are as follows:

Grading 177 acres @ $4,500	=	$796,500.00
Planting 177 acres @ $484	=	85,668.00
Total	=	$882,168.00

AREA T

This area is mine spoil covering approximately 16 acres. This area has been restored subsequent to mining and depressions which could act as ground water recharges. No highwalls are known to be present. This area is tributary to Stream 1-11 (Little Licking Creek) and contributes approximately 5% of the total pollution to Little Licking Creek (245 pounds of acid per day and 2062 pounds of sulfate per day) and approximately 2% of the total pollution present at the mouth of Licking Creek.

Location is east of Sligo south of Pennsylvania Route #68 adjacent to spoil pile S.

Reclamation will involve the movement of 255,776 c.y. of spoil refuse and the planting of 16 acres.

Costs are as follows:

Grading 16 acres @ $4,500	=	$72,000.00
Planting 16 acres @ $484	=	7,744.00
Total	=	$79,744.00

AREA U

This area is spoil covering approximately 28 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-11 and contributes approximately 3.9% of the total pollution of stream 1-11 (196 pounds of acid per day and 1,613 pounds of sulfate per day) and approximately 1.4% of the total pollution present at the mouth of Licking Creek.

Location is 1.1 miles southeast of Sligo along 16022.

Reclamation will involve the movement of 38,920 c.y. of spoil and the planting of 28 acres.

Costs are as follows:

Grading 28 acres @ $4,500	=	$126,000.00
Planting 28 acres @ $484	=	13,552.00
Total	=	$139,552.00

AREA V

This area is spoil covering approximately 6 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-11 and contributes approximately 0.8% of the total pollution of stream 1-11 (39 pounds of acid per day and 328 pounds of sulfate per day) and approximately 0.3% of the total pollution present at the mouth of Licking Creek.

Location is 1.6 miles southeast of Sligo along 16022.

Reclamation will involve the movement of 8,340 c.y. of spoil and the planting of 6 acres.

Costs are as follows:

Grading 6 acres @ $4,500	=	$27,000.00
Planting 6 acres @ $484	=	2,904.00
Total	=	$29,904.00

AREA W

This area is mine spoil covering approximately 139 acres. This area has been restored subsequent to mining and has depressions which could act as ground water recharges. No highwalls are present. This area is tributary to Stream 1-11 (Little Licking Creek) and contributes approximately 24% of the total pollution to Little Licking Creek (1,157 pounds of acid per day and 9,728 pounds of sulfate per day) and approximately 8% of the total pollution present at the mouth of Licking Creek.

Location is east of Sligo, south of State Route #68 adjacent to spoil pile T.

Reclamation will involve the movement of 193,210 c.y. of spoil refuse and the planting of 139 acres.

Costs are as follows:

Grading 139 acres @ $4,500	=	$625,500.00
Planting 139 acres @ $484	=	67,276.00
Total	=	$692,776.00

AREA X

This area is mine spoil covering approximately 83 acres. This area has been restored subsequent to mining and has depressions which could act as ground water recharges. Approximately 1,400 lineal feet of highwalls is present. The area is tributary to Stream 1-11 (Little Licking Creek) and contributes approximately 14% of the total pollution to Little Licking Creek (691 pounds of acid per day and 5,805 pounds of sulfate per day)' and approximately 5% of the total pollution present at the mouth of Licking Creek.

Location is east of Sligo, south of State Route #68 adjacent to spoil pile Y.

Reclamation will involve the movement of 885,986 c.y. of spoil refuse and the planting of 139 acres and the sealing of 1,400 l.f. of high wall to a height of approximately 25 feet.

Costs are as follows:

Grading 139 acres @ $4,500	=	$625,500.00
Planting 139 acres @ $484	=	67,276.00
Highwall sealing 3,889 s.y. @ $2.04	=	7,934.00
Total	=	$700,710.00

AREA Y

This area is mine spoil covering approximately 19 acres. This area has been restored subsequent to mining and has depressions which could act as ground water recharges. No highwalls are present. The area is tributary to Stream 1-11 (Little Licking Creek) and contributes approximately 34% of the total pollution to Little Licking Creek (159 pounds of acid per day and 1,338
pounds of sulfate per day) and approximately 1% of the total pollution present at the mouth of Licking Creek.

Location is southeast of Sligo and east of State Route #68.

Reclamation will involve the movement of 26,410 c.y. of spoil refuse and the planting of 19 acres.

Costs are as follows:

Grading 19 acres @ $4,500	=	$85,500.00
Planting 19 acres @ $484	=	9,196.00
Total	=	$94,696.00

AREA Z

This area is spoil covering approximately 106 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-01 and contributes approximately 92% of the total pollution of stream 1-01-01 (323 pounds of acid per day and 14,123 pounds of sulfate per day) and approximately 2.3% of the total pollution present at the mouth of Licking Creek.

Location is 2.5 miles southwest of Callensburg along T341.

Reclamation will involve the movement of 147,340 c.y. of spoil and the planting of 106 acres.

Costs are as follows:

Grading 106 acres @ $4,500	=	$477,000.00
Planting 106 acres @ $484	=	51,304.00
Total	=	$528,304.00

AREA DD

This area is spoil covering approximately 56 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01 and contributes approximately (96 pounds of acid per day and 1,946 pounds of sulfate per day) and approximately .73% of the total pollution present at the mouth of Licking Creek.

Location is 2.5 miles north of Rimersburg along 16019.

Reclamation will involve the movement of 606,144 c.y. of spoil and the planting of 56 acres.

Costs are as follows:

Grading 56 acres @ $4,500	=	$252,000.00
Planting 56 acres @ $484	=	27,104.00
Total	=	$279,104.00

AREA EE

This area is spoil covering approximately 112 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-08, 1-01-10, 1-01 and contributes approximately (24 pounds of acid per day and 1,680 pounds of sulfate per day) and approximately .17% of the total pollution present at the mouth of Licking Creek.

Location is 3.4 miles south of Callensburg along 16019.

Reclamation will involve the movement of 155,680 c.y. of spoil and the planting of 112 acres.

Costs are as follows:

Grading 112 acres @ $4,500	=	$504,000.00
Planting 112 acres @ $484	=	54,208.00
Total	=	$558,208.00

AREA FF

This area is spoil covering approximately 32 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01, 1-01-05 and contributes approximately (4 pounds of acid per day and 36 pounds of sulfate per day) and approximately .03% of the total pollution present at the mouth of Licking Creek.

Location is 2.5 miles south of Callensburg along 16019.

Reclamation will involve the movement of 44,480 c.y. of spoil and the planting of 32 acres.

Costs are as follows:

Grading 32 acres @ $4,500	=	$144,000.00
Planting 32 acres @ $484	=	15,488.00
Total	=	$159,488.00

AREA GG

This area is spoil covering approximately 138 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Streams 1-01, 1-01-02 and 1-01-06 and contributes approximately (79 pounds of acid per day and 2,105 pounds of sulfate per day) and approximately 0.6% of the total pollution present at the mouth of Licking Creek.

Location is 2.3 miles south of Callensburg along L.R. 16019.

Reclamation will involve the movement of 191,820 c.y. of spoil and the planting of 138 acres.

Costs are as follows:

Grading 138 acres @ $4,500	=	$621,000.00
Planting 138 acres @ $484	=	66,792.00
Total	=	$687,792.00

AREA HH

This area is spoil covering approximately 115 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-17 and contributes approximately 94.7% of the total pollution of stream 1-ol-17 (9 pounds of acid per day and 791 pounds of sulfate per day) and approximately .06% of the total pollution present at the mouth of Licking Creek.

Location is 1.0 mile south of Cherry Run Campground along T374.

Reclamation will involve the movement of 847,642 c.y. of spoil and the planting of 115 acres.

Costs are as follows:

Grading 115 acres @ $4,500	=	$517,500.00
Planting 115 acres @ $484	=	55,660.00
Total	=	$573,160.00

AREA II

This area is spoil covering approximately 41 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Streams 1-01, 1-01-08, 1-01-20 and contributes approximately (71 pounds of acid per day and 1,436 pounds of sulfate per day) and approximately .53% of the total pollution present at the mouth of Licking Creek.

Location is 1.4 miles south of Cherry Run Campground along T374.

Reclamation will involve the movement of 56,990 c.y. of spoil and the planting of 41 acres.

Costs are as follows:

Grading 41 acres @ $4,500	=	$184,500.00
Planting 41 acres @ $484	=	19,844.00
Total	=	$204,344.00

AREA JJ

This area is spoil covering approximately 21 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-16 and contributes approximately 62% of the total pollution of stream 1-01-16 (135 pounds of acid per day and 1,283 pounds of sulfate per day) and approximately .95% of the total pollution present at the mouth of Licking Creek.

Location is 1.7 miles north of Rimersburg along 16019.

Reclamation will involve the movement of 29,190 c.y. of spoil and the planting of 21 acres.

Costs are as follows:

Grading 21 acres @ $4,500	=	$ 94,500.00
Planting 21 acres @ $484	=	10,164.00
Total	=	$104,664.00

AREA KK

This area is spoil covering approximately 13 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-16 and contributes approximately 38% of the total pollution of stream 1-01-16 (82 pounds of acid per day and 779 pounds of sulfate per day) and approximately .58% of the total pollution present at the mouth of Licking Creek.

Location is 1.4 miles north of Rimersburg along 16019.

Reclamation will involve the movement of 18,070 c.y. of spoil and the planting of 13 acres.

Costs are as follows:

Grading 13 acres @ $4,500	=	$58,500.00
Planting 13 acres @ $484	=	6,292.00
Total	=	$64,792.00

AREA 00

This area is spoil covering approximately 191 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Streams 1-18, 1-20, 1-22 and contributes approximately (381 pounds of acid per day and 6,407 pounds of sulfate per day) and approximately 2.69% of the total pollution present at the mouth of Licking Creek.

Location is 2.4 miles east of Sligo along 68.

Reclamation will involve the movement of 330,282 c.y. of spoil and the planting of 191 acres.

Costs are as follows:

Grading 191 acres @ $4,500	=	$859,500.00
Planting 191 acres @ $484	=	92,444.00
Total	=	$951,944.00

AREA PP

This area is spoil covering approximately 6 acres. The area consists of low mounds of spoil with depressions between the mounds. No highwalls are known to be present. This area is tributary to Stream 1-01-17 and contributes approximately 5.3% of the total pollution of stream 1-01-17 (1 pounds of acid per day and 42 pounds of sulfate per day) and approximately .01% of the total pollution present at the mouth of Licking Creek.

Location is 1.0 mile south of Cherry Run Campground along T374.

Reclamation will involve the movement of 8,340 c.y. of spoil and the planting of 6 acres.

Costs are as follows:

Grading 6 acres @ $4,500	=	$27,000.00
Planting 6 acres @ $484	=	2,904.00
Total	=	$29,904.00

AREA a

This area is refuse covering approximately 3 acres. This area is tributary to Stream 1-01-14 and contributes approximately 0.9% of the total pollution of stream 1-01-14 (37 pounds of acid per day and 147 pounds of sulfate per day) and approximately 0.3% of the total pollution present at the mouth of Licking Creek.

Location is 0.1 mile north of Huey along 16021.

Reclamation will involve the movement of 4,170 c.y. of spoil and the planting of 3 acres.

Costs are as follows:

Grading 3 acres @ $4,500	=	$13,500.00
Planting 3 acres @ $484	=	1,452.00
Total	=	$14,952.00

AREA e

This area is refuse covering approximately 2 acres. This area is tributary to Stream 1-18 and contributes approximately 1.14% of the total pollution of Stream (3 pounds of acid per day and 61 pounds of sulfate per day) and approximately .02% of the total pollution present at the mouth of Licking Creek.

Location is 2.8 miles northeast of Sligo along T432.

Reclamation will involve the movement of 2,780 c.y. of spoil and the planting of 2 acres.

Costs are as follows:

Grading 2 acres @ $4,500	=	$9,000.00
Planting 2 acres @ $484	=	968.00
Total	=	$9,968.00

AREA f

This area is refuse covering approximately 1 acre. This area is tributary to Stream 1-08 and contributes approximately 0.1% of the total pollution of Stream 1-08 (2 pounds of acid per day and 15 pounds of sulfate per day) and approximately 0% of the total pollution present at the mouth of Licking Creek.

Location is 3.8 miles northeast of Sligo along 854.

Reclamation will involve the movement of 1,390 c.y. of spoil and the planting of 1 acre.

Costs are as follows:

Grading 1 acre @ $4,500	=	$4,500.00
Planting 1 acre @ $484	=	484.00
Total	=	$4,984.00

Future Mining

Several meetings were held with representatives of the C & K Coal Company where they verbally outlined their plans for continued mining within the Licking Creek Watershed (see Exhibit XIII).

The areas of major interest lie within the lower three-quarters of the watershed (see Exhibit No. XIV). Portions of this area have been mined in the past with little or no attempt made at reclamation. With the continuation of mining in this area, there exists the possibility that a program could be pursued that would include not only mineral extraction but also restoration of premined areas.

Considering the above information, two options were developed as follows: Option 1, the mining company responsible for the areas outlined on Exhibit XIII and the Department of Environmental Resources responsible for the areas outlined on Exhibit XIV; Option 2, the mining company responsible for the areas outlined on Exhibit XII plus those areas which are immediately adjacent and the Department of Environmental Resources responsible for the remaining area. Prices were used as computed under the "Specific Abatement Recommendations - Specific Areas" for the areas unaffected by future mining. In those instances where partial areas are considered, the costs were reduced by the percentage that the partial areas are to the original areas.

Total cost of all proposed reclamation is $13,598,055.00.

Cost of Option 1 is $5,303,510.00 and Option 2 is $3,438,112.00, as presented on Tables 7-3 and 7-4.

Abatement Plan *

With the possibilities as outlined in the preceding section, "Future Mining," the least costly and most effective abatement plan would be to issue mine permits contingent upon the operator reclaiming the entire disturbed area adjacent to active mining operations and the Department of Environmental Resources becoming financially responsible for the balance of abatement work in the watershed. This plan would be as outlined in Option 2 of the preceding section for a total cost of $3,438,112.00. Assuming an effectiveness of 75%, this would result in an abatement of 10,603 pounds of acid per day at a cost of $324.00 per pound. This would result in a stream loading at the mouth of Licking Creek after completion of abatement of 3,534 pounds of acid per day. Assuming a stream flow of 110 cfs, this loading would result from a concentration of 6 ppm, which from field sampling experience in the watershed would indicate an acceptable condition of pH values between 6 and 9.

* See Tables (7-5 through 7-8)

Effects of Abatement Action

The estimating of the effectiveness of the abatement measures is a problem with many variables such as the amount of infiltration reduction, the increase of the Cot level in the soil, due to plant life the amount of acid previously produced and present as soluble iron salts which may be leached from the spoil, and the type of flow system (deep or shallow) which carries the polluted water from the spoil areas. It is practically impossible to determine finite values for all variables contained in these equations, the most practicable method of solution being the construction of a mathematical model for computer use. Even the use of such a model would necessitate a certain amount of speculation as to values of the variables. Since the undertaking of such a model is beyond the scope of this study, some arbitrary value must be established as to the effectiveness of abatement measures. To assume an effectiveness of 100% would be unreasonable; therefore, the effectiveness of abatement has been assumed to be between 50% and 75% reduction of pollution from areas having been subjected to recommended abatement procedures. In order to present both high and low values for abatement effectiveness, local effects, cost benefits and total abatement effects are presented on Tables 7-5 through 7-8.

TABLE 7-3

RECLAMATION COSTS (OPTION 1)

SPECIFIC AREA				RECLAMATION COST
Area G	=			$ 304,024
Area H	=			$ 139,984
Area I	($977,408)	(0.33)	=	$ 322,545
Area MM	=			$ 89,712
Area QQ	=			$ 159,488
Area ZB	=			$ 520,008
Area ZA	=			$ 565,283
Area AA	=			$ 109,648
Area BB	=			$ 155,703
Area LL	=			$ 551,966
Area b	=			$ 34,888
Area g	=			$ 79,744
Area A	(119,616)	(0.50)	=	$ 59,808
Area J	(234,248)	(0.50)	=	$ 117,124
Area K	=			$ 393,736
Area O	=			$ 24,920
Area P	=			$ 19,936
Area Q	=			$ 29,904
Area S	(882,168)	(0.75)	=	$ 661,626
Area T	(79,744)	(0.75)	=	$ 59,808
Area V	=			$ 29,904
Area Z	(528,304)	(0.33)	=	$ 174,340
Area DD	(279,104)	(0.50)	=	$ 139,552
Area II	(204,344)	(0.93)	=	$ 190,040
Area JJ	=			$ 104,664
Area KK	=			$ 64,792
Area OO	(951,944)	(0.20)	=	$ 190,389
Area PP	=			$ 29,904
Area a	=			$ 14,952
Area e	=			$ 9,968
Area f	=			$ 4,984
Total				$ 5,303,510

TABLE 7-4

RECLAMATION COSTS (OPTION 2)

SPECIFIC AREA		RECLAMATION COST
Area G	=	$ 304,024
Area H	=	$ 139,984
Area I	=	$ -0-
Area MM	=	$ 89,712
Area QQ	=	$ 159,488
Area ZB	=	$ 520,008
Area ZA	=	$ 565,283
Area AA	=	$ 109,648
Area BB	=	$ 155,703
Area LL	=	$ 551,966
Area b	=	$ 34,888
Area g	=	$ 79,744
Area A	=	$ -0-
Area J	=	$ -0-
Area K	=	$ 393,736
Area O	=	$ 24,920
Area P	=	$ 19,936
Area Q	=	$ 29,904
Area S	=	$ -0-
Area T	=	$ -0-
Area V	=	$ 29,904
Area Z	=	$ -0-
Area DD	=	$ -0-
Area II	=	$ -0-
Area JJ	=	$ 104,664
Area KK	=	$ 64,792
Area OO	=	$ -0-
Area PP	=	$ 29,904
Area a	=	$ 14,952
Area e	=	$ 9,968
Area f	=	$ 4,984
Total	=	$ 3,438,112

TABLE 7-5

ABATEMENT EFFECTIVENESS ANALYSIS

SUB-WATERSHED	AREA	COST OF ABATEMENT (IN DOLLARS)	PRESENT PRODUCTION		PRODUCTION WITH 50% EFFECTIVENESS		EFFECTS ON SUB-WATERSHED FOR 50% POLLUTION REDUCTION								EFFECT ON MAIN STREAM FOR 50% POLLUTION REDUCTION								COST PER POUND OF POLLUTANT REMOVED (IN DOLLARS)		REMARKS
							ABATED				REMAINING				ABATED				REMAINING						
			ACID				ACID		SO_4		ACID		SO_4		ACID		SO_4		ACID		SO_4				
			ACID #/DA.	SO_4 #/DA.	ACID #/DA.	SO_4 #/DA.	#/DA	%	#/DA.	%	#/DA.	%	#/DA.	%	#/DA	%	#/DA.	%	#/DA.	%	#/DA.	%	ACID	SO_4	
1-08	N	49,840	199.	1,991.	99	995	100	6.8	996	6.8	1,365	93.2	13,632	93.2	100	0.7	996	0.6	14,037	99.3	161,875	99.4	498	50	ENTIRELY PERMITTED
1-08	f	4,984	18.	179.	9	89	9	0.6	90	0.6	1,456	99.4	14,538	99.4	9	0.1	90	0.1	14,128	99.9	162,781	99.9	554	55	
1, 1-10,1-12,1-14	I	977,408	3,830.	13,657.	1,915	6,828	1,915	NA	6,829	NA.	NA.	NA.	NA.	NA.	1,915	135	6,829	4.2	12,222	86.5	156,042	95.8	36	143	PART.PERMIT,FUTURE MINE
1-10	L	69,776	271.	968.	135.	484	136	2.4	484	2.4	5,568	97.6	19,857	97.6	136	1.0	484	0.3	14,001	99.0	162,387	99.7	513	144	ENTIRELY PERMITTED
1-10	MM	89,712	351.	1,251	175	625	176	3.1	626	3.1	5,528	96.9	19,715	96.9	176	1.2	626	0.4	13,961	98.8	162,245	99.6	510	143	
1-10	H	139,984	612.	2,183	306	1,091	306	5.4	1,092	5.4	5,398	94.6	19,249	94.6	306	2.2	1,092	0.7	13,831	97.7	161,730	99.3	457	128	
1-10,1-16,1-18	QQ	159,488	640.	2,282	320	1,141	320	NA	1,141	NA	NA	NA	NA	NA	320	2.3	1,141	0.7	13,817	97.7	161,730	99.3	498	140	
1, 1-11	S	882,168	352.	2,955	176	1,477	176	NA	1,478	NA	NA	NA	NA	NA	176	1.2	1,478	0.9	13,961	98.8	161,393	99.1	5012	597	PARTIALLY PERMITTED
1-11	T	79,744	245.	2,062	122	1,031	123	2.5	1,031	2.5	4,797	97.5	40,320	97.5	123	0.9	1,031	0.6	14,014	99.1	161,840	99.4	648	77	PARTIALLY PERMITTED
1-11	W	692,776	1,157	9,728	578	4,864	579	11.8	4,864	11.8	4,341	88.2	36,487	88.2	579	4.1	4,864	3.0	13,558	95.9	158,007	97.0	1197	142	ENTIRELY PERMITTED
1-11	X	700,710	691.	5,805	345	2,902	346	7.0	2,903	7.0	4,574	93.0	38,448	93.0	346	2.4	2,903	1.8	13,791	97.6	159,968	98.2	2025	241	ENTIRELY PERMITTED
1-11	Y	94,696	159.	1,338	79	669	80	1.6	669	1.6	4,840	98.4	40,682	98.4	80	0.6	669	0.4	14,057	99.4	162,202	99.6	1184	142	ENTIRELY PERMITTED
1-11	RR	99,680	164.	1,374	82	687	82	1.7	687	1.7	4,838	98.3	40,664	98.3	82	0.6	687	0.4	14,055	99.4	162,184	99.6	1216	145	
1-11	SS	635,982	1,025	8,614	512	4,307	513	10.4	4,307	10.4	4,407	89.6	37,044	89.6	513	3.6	4,307	2.6	13,624	96.4	158,564	97.4	1240	148	PART.PERMIT,FUTURE MINE
1-11	ZB	520,008	852	7,164	426	3,582	426	8.7	3,582	8.7	4,494	91.3	37,769	91.3	426	3.0	3,582	2.2	13,711	97.0	159,289	97.8	1221	145	
1, 1-11	U	139,552	229	1,926	114	963	115	NA	963	NA	NA	NA	NA	NA	115	0.8	963	0.6	14,022	99.2	161,908	99.4	1213	145	
1-11	V	29,904	46.	385.	23	192	23	0.5	193	0.5	4,897	99.5	41,158	99.5	23	0.2	193	0.1	14,114	99.8	162,678	99.9	1300	155	ENTIRELY PERMITTED
1-01-14	ZA	565,283	1,442	5,697	721	2,848	721	17.5	2,849	17.5	3,405	82.5	13,451	82.5	721	5.1	2,849	1.7	13,416	94.9	160,022	98.3	784	198	
1-01-14	AA	109,648	293	1,159	146	579	147	3.6	580	3.6	3,979	96.4	15,720	96.4	147	1.0	580	0.4	13,990	99.0	162,291	99.6	746	189	
1-01-14	BB	155,703	378	1,493	189	746	189	4.6	747	4.6	3,937	95.4	15,553	95.4	189	1.3	747	0.5	13,948	98.7	162,124	99.5	824	208	
1-01-14	CC	108,721	252	997	126	498	126	3.1	499	3.1	4,000	96.9	15,801	96.9	126	0.9	499	0.3	14,011	99.1	162,372	99.7	863	218	ENTIRELY FUTURE MINED
1-01-14	LL	551,966	1,413	5,583	706	2,791	707	17.1	2,792	17.1	3,419	82.9	13,508	82.9	707	5.0	2,792	1.7	13,430	95.0	160,079	98.3	781	198	
1-01-14	b	34,888	101	397	50	198	51	1.2	199	1.2	4,075	98.8	16,101	98.8	51	0.4	199	0.1	14,086	99.6	162,672	99.9	684	175	
1-01-14	g	79,744	210	828	105	414	105	2.5	414	2.5	4,021	97.5	15,886	97.5	105	0.7	414	0.3	14,032	99.3	162,457	99.7	759	193	
1-01-14	a	14,952	37	146	18	73	19	0.5	73	0.4	4,107	99.5	16,227	99.6	19	0.1	73	0.0	14,118	99.9	162,798	100.0	787	205	

NA INDICATES AREA UNDER DISCUSSION LIES IN MORE THAN ONE SUB-WATERSHED, OR TOTALLY WITHIN MAIN WATERSHED.

TABLE 7-6

ABATEMENT EFFECTIVENESS ANALYSIS

SUB WATERSHED	AREA	COST OF ABATEMENT (IN DOLLARS)	PRESENT PRODUCTION		PRODUCTION WITH 75% EFFECTIVENESS		EFFECTS ON SUB-WATERSHED FOR 75% POLLUTION REDUCTION								EFFECT ON MAIN STREAM FOR 75% POLLUTION REDUCTION								COST PER POUND OF POLLUTANT REMOVED (IN DOLLARS)		REMARKS
							ABATED				REMAINING				ABATED				REMAINING						
			ACID				ACID		SO_4		ACID		SO_4		ACID		SO_4		ACID		SO_4				
			ACID #/DA.	SO_4 #/DA.	ACID #/DA	SO_4 #/DA	#/DA	%	#/DA	%	#/DA	%	#/DA	%	#/DA	%	#/DA	%	#/DA.	%	#/DA.	%	ACID	SO_4	
1-08	N	49840	199	1,991	50	498	149	10.2	1,493	10.2	1,316	89.8	13,135	89.8	149	1.1	1,493	0.9	13,988	98.9	161,378	99.1	334	33	ENTIRELY PERMITTED
1-08	f	4984	18	179	4	45	14	1.0	134	1.9	1,451	99.0	14,494	99.1	14	0.1	134	0.1	14,123	99.9	162,737	99.9	356	37	
1,1-10,1-12-1-14	I	977,408	3,830	13,657	957	3,414	2,873	NA	10,243	NA	NA	NA	NA	NA	2,873	20.3	10,243	6.3	11,264	79.7	152,628	93.7	340	95	PART.PERMIT,FUTURE MINE
1-10	L	69,776	271	968	68	242	203	3.6	726	3.6	5,501	96.4	19,615	96.4	203	1.4	726	0.4	13,934	98.6	162,145	99.6	344	96	ENTIRELY PERMITTED
1-10	MM	89,712	351	1,251	88	313	263	4.6	938	4.6	5,441	95.4	19,403	95.4	263	1.9	938	0.6	13,874	98.1	161,933	99.4	341	96	
1-10	H	139,984	612	2,183	153	546	459	8.0	1,637	8.0	5,245	92.0	18,704	92.0	459	3.2	1,637	1.0	13,678	96.8	161,234	99.0	305	86	
1-10,1-16,1-18	QQ	159,488	640	2,282	160	570	480	NA	1,712	NA	NA	NA	NA	NA	480	3.4	1,712	1.1	13,657	96.6	161,159	98.9	332	93	
1,1-11	S	882,168	352	2,955	88	739	264	NA	2,216	NA	NA	NA	NA	NA	264	1.9	2,216	1.4	13,873	98.1	160,655	98.6	3342	398	PARTIALLY PERMITTED
1-11	T	79,744	245	2,062	61	515	184	3.7	1,547	3.7	4,736	96.3	39,804	96.3	184	1.3	1,547	0.9	13,953	98.7	161,324	99.1	433	52	PARTIALLY PERMITTED
1-11	W	692,776	1,157	9,728	289	2,432	868	17.6	7,296	17.6	4,052	82.4	34,055	82.4	868	6.1	7,296	4.5	13,269	93.9	155,575	95.5	798	95	ENTIRELY PERMITTED
1-11	X	700,710	691	5,805	173	1,451	518	10.5	4,354	10.5	4,402	89.5	36,997	89.5	518	3.7	4,354	2.7	13,619	96.3	158,517	97.3	1353	161	ENTIRELY PERMITTED
1-11	Y	94,696	159	1,338	40	334	119	2.4	1,004	2.4	4,801	97.6	40,347	97.6	119	0 8	1,004	0.6	14,018	99.2	161,867	99.4	796	94	ENTIRELY PERMITTED
1-11	RR	99,680	164	1,374	41	343	123	2.5	1,031	2.5	4,797	97.5	40,320	97.5	123	0.9	1,031	0.6	14,014	99.1	161,840	99.4	810	97	
1-11	SS	635,982	1,025	8,614	256	2,153	769	15.6	6,461	15.6	4,151	84.4	34,890	84.4	769	5.4	6,461	4.0	13,368	94.6	156,410	96.0	827	98	PART.PERMIT,FUTURE MINE
1-11	ZB	520,038	852	7,164	213	1,791	639	13.0	5,373	13.0	4,281	87.0	35,978	87.0	639	4.5	5,373	3.3	13,498	95.5	157,498	96.7	814	97	
1,1-11	U	139,552	229	1,926	57	481	172	NA	1,445	NA	NA	NA	NA	NA	172	1.2	1,447	0.9	13,965	98.8	161,424	99.1	811	96	
1-11	V	29,904	46	385	11	96	35	0.7	289	0.7	4,885	99.3	41,062	99.3	35	0.2	289	0.2	14,102	99.8	162,582	99.8	854	103	ENTIRELY PERMITTED
1-01-14	ZA	565,283	1,442	5,697	360	1,424	1,082	26.2	4,273	26.2	3,044	73.8	12,027	73.8	1,082	7.7	4,273	2.6	13,055	92.3	158,598	97.4	522	132	
1-01-14	AA	109,648	293	1,159	73	290	220	5.3	869	5.3	3,906	94.7	15,431	94.7	220	1.6	869	0.5	13,917	98.4	162,002	99.5	498	126	
1-01-14	BB	155,703	378	1,493	94	373	284	6.9	1,120	6.9	3,842	93.1	15,180	93.1	284	2.0	1,120	0.7	13,853	98.0	161,751	99.3	548	139	
1-01-14	CC	108,721	252	997	63	249	189	4.6	748	4.6	3,937	95.4	15,552	95.4	189	1.3	748	0.5	13,948	98.7	162,123	99.5	575	145	ENTIRELY FUTURE MINED
1-01-14	LL	551,966	1,413	5,583	353	1,396	1,060	25.7	4,187	25.7	3,066	74.3	12,113	74.3	1,060	7.5	4,187	2.6	13,077	92.5	158,684	97.4	521	132	
1-01-14	b	34,888	101	397	25	99	76	1.8	298	1.8	4,050	98.2	16,002	98.2	76	0.5	298	0.2	14,061	99.5	162,573	99.8	459	117	
1-01-14	g	79,744	210	828	52	207	158	3.8	621	3.8	3,968	96.2	15,679	96.2	158	1.1	621	0.4	13,979	98.9	162,250	99.6	505	128	
1-01-14	a	14,952	37	146	9	36	28	0.7	110	0.7	4,098	99.3	16,190	99.3	28	0.2	110	0.1	14,109	99.8	162,761	99.9	534	136	

NA. INDICATES AREA UNDER DISCUSSION LIES IN MORE THAN ONE SUB-WATERSHED, OR TOTALLY WITHIN MAIN WATERSHED.

TABLE 7-7

ABATEMENT EFFECTIVENESS ANALYSIS

SUB-WATERSHED	AREA	COST OF ABATEMENT (IN DOLLARS)	PRESENT PRODUCTION		PRODUCTION WITH 50% EFFECTIVENESS		EFFECTS ON SUB-WATERSHED FOR 50% POLLUTION REDUCTION								EFFECTS ON MAIN STREAM FOR 50% POLLUTION REDUCTION								COST PER POUND OF POLLUTANT REMOVED (IN DOLLARS)		REMARKS
							ABATED				REMAINING				ABATED				REMAINING						
			ACID	SO_9	ACID	SO_4	ACID		SO_4		ACID		SO_4		ACID		SO_4		ACID		SO_4		ACID	SO_4	
			#/DA.	#/DA.	#/DA.	#/DA.	#/DA.	%	#/DA.	%	#/DA.	%	#/DA.	%	#/DA.	%	#/DA.	%	#/DA.	%	#/DA.	%			
1-05, 1-07, 1	E	338,912	162.	3498.	81.	1749.	81.	NA	1749.	NA	NA	NA	NA	NA	81.	0.6	1749.	1.1	14056.	99.4	161,122.	98.9	4184	194	ENTIRELY PERMITTED
1-01-16	KK	64,792	82.	779.	41.	389.	41.	18.9	390.	18.9	176.	81.1	1672.	81.1	41.	0.3	390.	0.2	14096.	99.7	162,481.	99.8	1580	166	
1-01-16	JJ	104664	135.	1283.	68.	642.	67.	30.9	641.	31.1	150.	69.1	1421.	68.9	67.	0.5	641.	0.4	14070.	99.5	162,230.	99.6	1562	163	
1-07	F	503,384	145.	2671.	73.	1336.	72.	40.6	1335.	41.0	105.	59.4	1925.	59.0	72.	0.5	1335.	0.8	14065.	99.5	161,536.	99.2	6991	377	ENTIRELY PERMITTED
1-18, 1-20, 1-22	OO	951,944	381.	6407.	191.	3204.	190.	NA	3203.	NA.	NA.	NA.	NA.	NA.	190.	1.3	3203.	1.9	13947.	98.7	159,668.	98.1	5010	297	PART.PERMIT,FUTURE MINE
1-14, 1-16	K	393,736	82.	599.	41.	300.	41.	NA.	299.	NA.	NA.	NA.	NA.	NA.	41.	0.3	299.	0.2	14096.	99.7	162,572	99.8	9603	1317	
1-18	O	24,920	7.	186.	4.	78.	3.	1.2	78.	1.4	254.	98.8	5311.	98.6	3.	0.	78.	0.	14134.	100.	162,793	100.	8307	319	
1-18	•	9,968	3.	61.	2.	31.	1.	0.4	30.	0.6	256.	99.6	5359	99.4	1.	0.	30.	0.	14136.	100.	162,841.	100.	9968	332	
1-18	P	19,936	6.	123.	3.	62.	3.	1.2	61.	1.1	254.	98.8	5328.	98.9	3.	0.	61.	0.	14134.	100.	162,810.	100.	6645	327	
1-18	Q	29,904	10.	216.	5.	108.	5.	1.9	108.	2.0	252.	98.1	5281.	98.0	5.	0.	108.	0.1	14132.	100.	162,763.	99.9	5981	277	
1-03	C	84,728	19.	244.	10.	122.	9.	47.4	122.	50.	10.	52.6	122.	50.0	9.	0.1	122.	0.1	14128.	99.9	162,749.	99.9	9414	694	ENTIRELY FUTURE MINED
1-12, 1	J	234,248	248.	1252.	124.	626.	124.	NA	626.	NA	NA.	NA.	NA.	NA.	124.	0.9	626.	0.4	14013.	99.1	162,245.	99.6	1889	374	PART.PERMIT,FUTURE MINE
1	D	19,936	7.	128.	4.	64.	3.	NA.	64.	NA.	NA.	NA.	NA.	NA.	3.	0.	64.	0.	14134.	100.	162,807.	100.	6645	312	ENTIRELY PERMITTED
1, 1-01	B	428,624	148.	2999.	74.	1500.	74.	NA.	1499.	NA.	NA.	NA.	NA.	NA.	74.	0.5	1499.	0.9	14063.	99.5	161,372.	99.1	5792	286	ENTIRELY FUTURE MINED
1-01-08, 1-01-10, 1-01	EE	558,208	24	1680.	12.	840.	12.	NA.	840.	NA.	NA.	NA.	NA.	NA.	12.	0.1	840.	0.5	14125.	99.9	161,031	99.5	46,517	665	ENTIRELY FUTURE MINED
1-01	DD	279,104	96.	1946.	48.	973.	48.	NA.	973.	NA.	NA.	NA.	NA.	NA.	48.	0.3	973.	0.6	14089.	99.7	161,898.	99.4	5815	287	PARTIALLY FUTURE MINED
1-01, 1-01-18, 1-01-20	II	204,344	71.	1436.	36.	718.	35.	NA.	718.	NA.	NA.	NA.	NA.	NA.	35.	0.2	718.	0.4	14102.	99.8	162,153.	99.6	5838	285	
1-01, 1-01-05	FF	159,488	4.	36.	2.	18.	2.	NA.	18.	NA.	NA.	NA.	NA.	NA.	2.	0.	18.	0.	14135.	100.	162,853.	100.	79744	8,860	ENTIRELY FUTURE MINED
1-01, 1-01-01	A	119,616	73.	3192.	37.	1596.	36.	NA.	1596.	NA.	NA.	NA.	NA.	NA.	36.	0.3	1596.	1.0	14101.	99.7	161,275.	99.	3323	75	PART.PERMIT,FUTURE MINE
1-01-01	Z	528,304	323.	14,123.	162.	7062.	161.	NA.	7061.	NA.	NA.	NA.	NA.	NA.	161.	1.1	7061.	4.3	13976.	98.9	155,810.	95.7	3281	75	PARTIALLY FUTURE MINED
1-01, 1-01-02, 1-01-06	GG	687,792	79.	2,105.	40.	1053.	39.	NA.	1052.	NA.	NA.	NA.	NA.	NA.	39.	0.3	1052.	0.6	14098.	99.7	161,819.	99.4	17636	654	ENTIRELY FUTURE MINED
1-01-17	HH	573,160	9.	791.	5.	396.	4.	40.	395.	47.4	6.	60.	438.	52.6	4.	0.	395.	0.2	14133.	100.	162,476.	99.8	143,290	1451	ENTIRELY FUTURE MINED
1-01-17	PP	29,904	1.	42.	1.	21.	0.	0.	21.	2.5	10.	100.	812.	97.5	0.	0.	21.	0.	14137.	100.	162,850.	100.	29,904	1,424	
1-08	G	304,024	1212.	12,097.	606.	6049.	606.	41.4	6049.	41.4	859.	58.6	8580.	58.6	606.	4.3	6049.	3.7	13,531	95.7	156,823	96.3	502	50	
1-08	M	9,968	36.	361.	18.	181.	18.	1.2	180.	1.2	1447.	98.8	14,808	98.8	18.	0.1	180.	0.1	14,119	99.9	162,691.	99.9	554	55	ENTIRELY PERMITTED

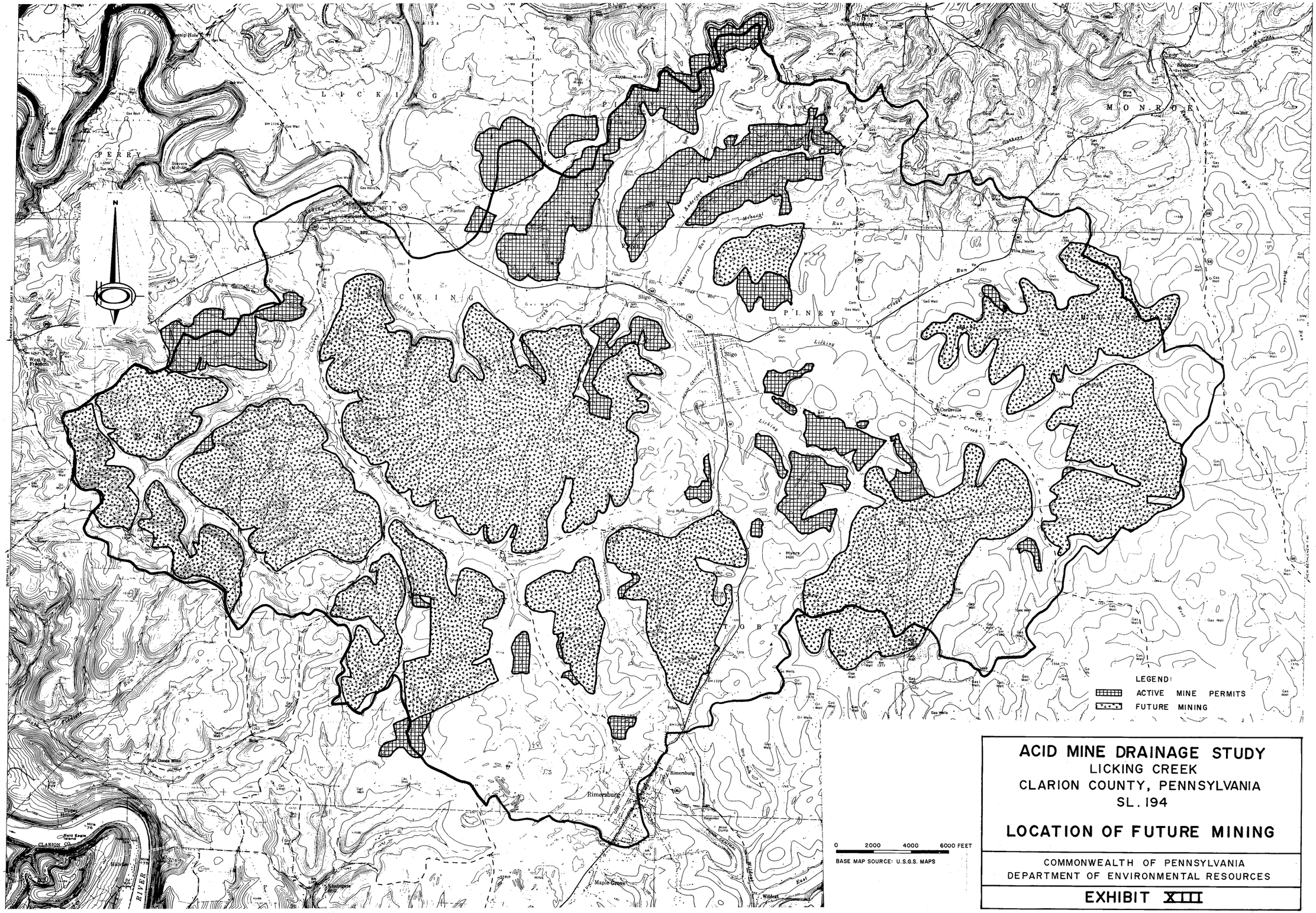
NA. INDICATES AREA UNDER DISCUSSION LIES IN MORE THAN ONE SUB-WATERSHED, OR TOTALLY WITHIN MAIN WATERSHED.

TABLE 7-8

ABATEMENT EFFECTIVENESS ANALYSIS

SUB-WATERSHED	AREA	COST OF ABATEMENT (IN DOLLARS)	PRESENT PRODUCTION		PRODUCTION WITH 75% EFFECTIVENESS		EFFECTS ON SUB-WATERSHED FOR 75% POLLUTION REDUCTION								EFFECT ON MAIN STREAM FOR 75% POLLUTION REDUCTION								COST PER POUND OF POLLUTANT REMOVED (IN DOLLARS)		REMARKS
							ABATED				REMAINING				ABATED				REMAINING						
			ACID				ACID		SO_4		ACID		SO_4		ACID		SO_4		ACID		SO_4				
			#/DA	SO_4 #/DA	ACID	SO_4	#/DA	%	#/DA.	%	#/DA	%	#/DA	%	#/DA	%	#/DA	%	#/DA	%	#/DA	%	ACID	SO_4	
1-05, 1-07, 1	E	338,912	162	3498	40	875	122	NA	2623	NA	NA	NA	NA	NA	122	0.9	2623	1.6	14015	99.1	160,248	98.4	2778	129	ENTIRELY PERMITTED
1-01-16	KK	64,792	82	779	20	195	62	28.6	584	28.3	155	71.4	1478	71.1	62	0.4	584	0.4	14,075	99.6	162,287	99.6	1045	111	
1-01-16	JJ	104,664	135	1283	34	321	101	46.6	962	46.7	116	53.4	1100	53.3	101	0.7	962	0.6	14,036	99.3	161,909	99.4	1036	109	
1-07	F	503,384	145	2671	36	668	109	61.6	2003	61.4	68.	38.4	1257	38.6	109	0.8	2003	1.2	14,028	99.2	160,868	98.8	4618	251	ENTIRELY PERMITTED
1-18, 1-20, 1-22	OO	951,944	381	6407	96	1602	286	NA	4805	NA	NA	NA	NA	NA	286	2.0	4805	3.0	13,851	98.0	158,066	97.0	3328	198	PART.PERMIT,FUTURE MINE
1-14, 1-16	K	393,736	82	599	20	150	62	NA	449	NA	NA	NA	NA	NA	62	0.4	449	0.3	14,075	99.6	162,422	99.7	6351	877	
1-18	O	24,920	7	156	2	39	5	1.9	117	2.2	252	98.1	5272	97.8	5	0	117	0.1	14,132	100.	162,754	99.9	4984	213	
1-18	•	9,968	3	61	1	16	2	0.8	46	0.9	255	99.2	5343	99.1	2	0	46	0	14,135	100	162,825	100	4984	217	
1-18	P	19,936	6	123	2	31	5	1.9	92	1.7	252	98.1	5297	98.3	5	0	92	0.1	14,132	100	162,779	99.9	3987	217	
1-18	Q	29,904	10	216	3	54	8	3.1	162	3.0	249	96.9	5227	97.0	8	0.1	162	0.1	14,129	99.9	162,709	99.9	3738	185	
1-03	C	84,728	19	244	5	61	14	73.7	183	75	5	26.3	61	25	14	0.1	183	0.1	14,123	99.9	162,688	99.9	6052	463	ENTIRELY FUTURE MINED
1-12, 1	J	234,248	248	1252	62	313	186	NA	939	NA	NA	NA	NA	NA	186	1.3	939	0.6	13,951	98.7	161,932	99.4	1259	249	PART.PERMIT,FUTURE MINE
1	D	19,936	7	128	2	32	5	NA	96	NA	NA	NA	NA	NA	5	0	96	0.1	14,132	100	162,775	99.9	3987	208	ENTIRELY PERMITTED
1, 1-10	B	428,624	148	2999	37	750	111	NA	2249	NA	NA	NA	NA	NA	111	0.8	2249	1.4	14,026	99.2	160,622	98.6	3861	191	ENTIRELY FUTURE MINED
1-01-08,1-01-10,1-01	EE	558,208	24	1680	6	420	18	NA	1260	NA	NA	NA	NA	NA	18	0.1	1260	0.8	14,119	99.9	161,611	99.2	31,011	443	ENTIRELY FUTURE MINED
1-01	DD	279,104	96	1946	24	487	72	NA	1460	NA	NA	NA	NA	NA	72	0.5	1460	0.9	14,065	99.5	161,411	99.1	3,876	191	PARTIALLY FUTURE MINED
1-01,1-01-18,1-01-20	II	204,344	71	1436	18	359	53	NA	1077	NA	NA	NA	NA	NA	53	0.4	1077	0.7	14,084,	99.6	161,794	99.3	3,856	190	
1-01, 1-01-05	FF	159,488	4	36	1	9	3	NA	27	NA	NA	NA	NA	NA	3	0	27	0	14,134	100	162,844	100	53,163	5,907	ENTIRELY FUTURE MINED
1-01, 1-01-01	A	119,616	73	3192	18	798	55	NA	2394	NA	NA	NA	NA	NA	55	0.4	2394	1.5	14,082	99.6	160,477	98.5	2,175	50	PART.PERMIT,FUTURE MINE
1-01-01	Z	528,304	323	14,123	81	3531	242	NA	10,592	NA	NA	NA	NA	NA	242	1.7	10,592	6.5	13,895	98.3	161,292	93.5	2183	50	PARTIALLY FUTURE MINED
1-01,1-01-02,1-01-06	GG	687,792	79	2,105	20	527	59	NA	1579	NA	NA	NA	NA	NA	59	0.4	1579	1.0	14,078	99.6	161,292	99.0	11,657	436	ENTIRELY FUTURE MINED
1-01-17	HH	573,160	9	791	3	198	7	70.	593	71.2	3	30.	240	28.8	7	0	593	0.4	14,130	100	162,278	99.6	81,880	967	ENTIRELY FUTURE MINED
1-01-17	PP	29,904	1	42	1	11	1	10	32	3.8	9	20	801	96.2	1	0	32	0	14,136	100	162,839	99.6	29,904	935	
1-08	G	304,024	1212	12097	303	3024	909	62	9073	62	556	38	5555	38	909	6.4	9073	5.6	13,228	93.6	153,798	94.9	334	34	
1-08	M	9,968	36	361	9	90	27	1.8	271	1.8	1438	98.2	14357	98.2	27	0.2	271	0.2	14,110	99.8	162,600	99.8	369	37	ENTIRELY PERMITTED

NA. INDICATES AREA UNDER DICUSSION LIES IN MORE THAN ONE SUB WATERSHED, OR TOTALLY WITHIN MAIN WATERSHED.

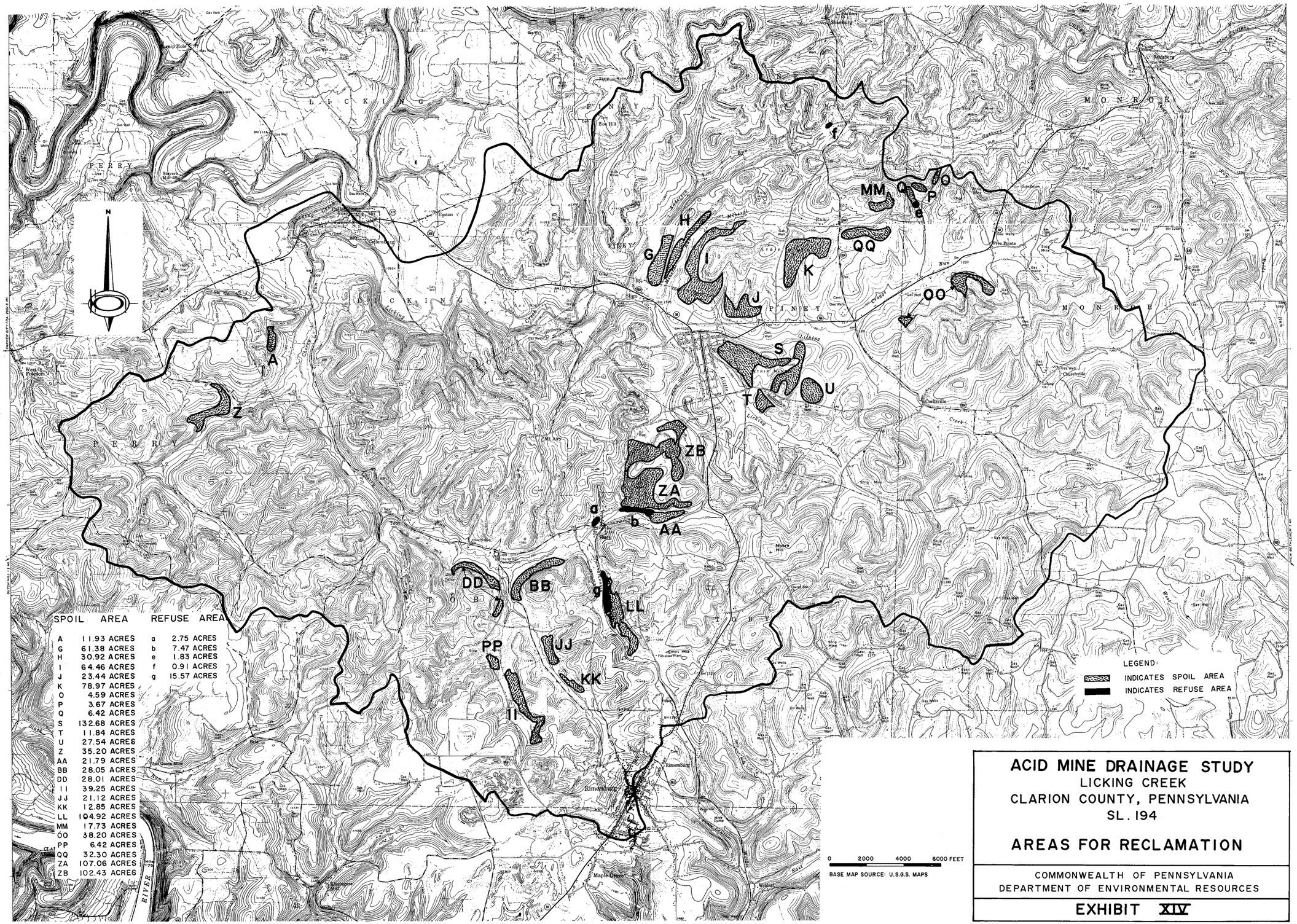


ACID MINE DRAINAGE STUDY
LICKING CREEK
CLARION COUNTY, PENNSYLVANIA
SL. 194

LOCATION OF FUTURE MINING

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

EXHIBIT XIII



SPOIL	AREA	REFUSE	AREA
A	11.93 ACRES	a	2.75 ACRES
G	61.38 ACRES	b	7.47 ACRES
H	30.92 ACRES	e	1.83 ACRES
I	64.46 ACRES	f	0.91 ACRES
J	23.44 ACRES	g	15.57 ACRES
K	78.97 ACRES		
O	4.59 ACRES		
P	3.67 ACRES		
Q	6.42 ACRES		
S	132.68 ACRES		
T	11.84 ACRES		
U	27.54 ACRES		
Z	35.20 ACRES		
AA	21.79 ACRES		
BB	28.05 ACRES		
DD	28.01 ACRES		
II	39.25 ACRES		
JJ	21.12 ACRES		
KK	12.85 ACRES		
LL	104.92 ACRES		
MM	17.73 ACRES		
OO	38.20 ACRES		
PP	6.42 ACRES		
QQ	32.30 ACRES		
ZA	107.06 ACRES		
ZB	102.43 ACRES		

ACID MINE DRAINAGE STUDY
LICKING CREEK
CLARION COUNTY, PENNSYLVANIA
SL. 194

AREAS FOR RECLAMATION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

EXHIBIT XIV