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# A MEASUREMENT OF THE EXTERNAL DISECONOMIES ASSOCIATED WITH BITUMINOUS COAL SURFACE MINING, EASTERN KENTUCKY, 1962-1967

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The purpose of this article is to suggest an approach in measuring both the assumed external diseconomies arising from surface mining and the internal expenses incurred by firms to reduce such social costs. These internal expenses are associated with reclaiming the surface-mined land. The term "external diseconomies" or social costs as used herein refers to all of those damages and harmful effects sustained by others as a result of productive processes, and for which the private firms are not held accountable; in addition, such costs must be avoidable and shifted to other persons or society in general. The various types of external diseconomies arising from each of the several sources within the mining site are calculated separately; charges to be incurred in future years are discounted to the year in which surface mining takes place. When further reclamation is performed, the average internal expenses and the average external costs are computed and compared.

For the purpose of exploring this approach, an examination is made herein of the internal expenses and assumed external diseconomies associated with the eastern Kentucky bituminous coal surface mining industry during the 1962-1967 period. The changes over this six-year period in the Kentucky law and regulations concerning the reclaiming of land disturbed by such surface mining<sup>1</sup> caused significant reductions in external costs imposed upon society in the form of damages from acid run-off water, silt and sediment material, landslides, losses by owners of the land surface only, and loss of aesthetic values. The more notable alterations in the reclamation provisions and their enforcement occurred in 1964 and 1966. These revisions changed the magnitude of each external cost source and its duration. In addition, the changes in reclamation requirements and enforcement procedures increased the mining firms' internal mining expenses.

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1. Unless otherwise indicated, the term "surface mining" as used herein refers to eastern Kentucky bituminous coal surface mining (auger plus strip).

External cost decreases and internal mining expense increases for the 1962-1967 period are computed and compared both on a per-disturbed acre and a per-ton-mined basis. This period is chosen in order to determine such annual costs before and after the 1964 as well as the 1966 revisions in reclamation procedures and enforcement. The specific external costs examined are:<sup>2</sup>

- Damages from acid run-off water
- Damages from silt and sediment materials
- Loss of aesthetic values
- Losses incurred by owners of the land surface only
- Losses caused by landslides

The calculated internal costs of the mining firms to perform the land reclamation include:

- Direct reclamation costs (land regrading and revegetation).
- State surface-mining permit and acreage fees.
- Performance bond fees.
- Other administrative costs.

The approach utilized herein may be useful in analyzing the costs and benefits associated with surface mining other than bituminous coal.

## I

### THE METHOD OF MEASUREMENT

#### A. *Types and Sources of External Costs*

The basic objectives of the Kentucky reclamation requirements are:

1. Reduction of external diseconomies caused by acid-run-off water.

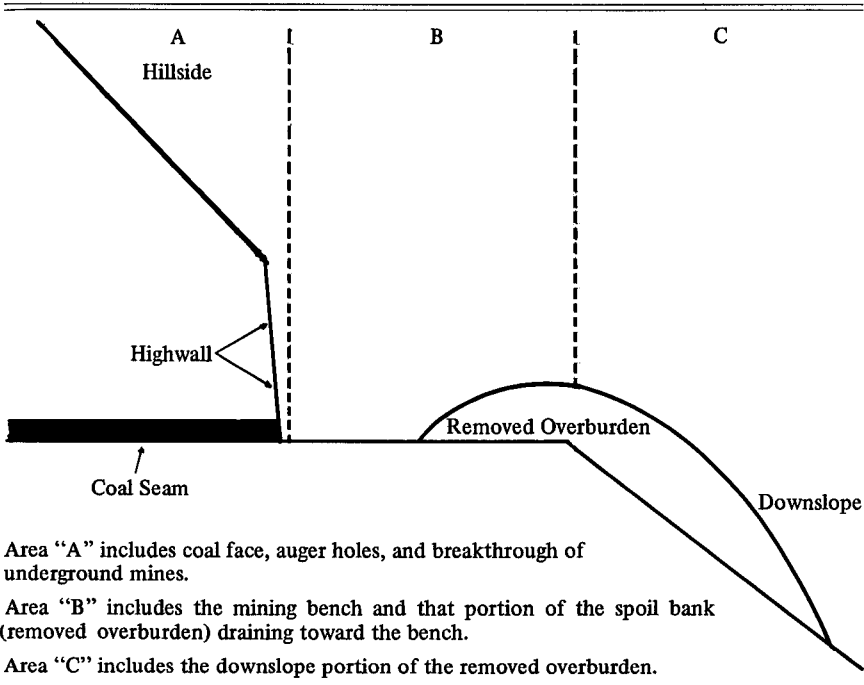
Sulfuritic minerals in the material in and around the coal seam are exposed during the mining process. These substances are carried from the mining site by storm run-off water. The pollution of streams and

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2. It is recognized that other external costs exist such as the damage to society by dust arising from the mining operations and from coal truck traffic, and damages to public roads and bridges by coal trucks above their share of road taxes. However, these external costs are not within the purview of the state law. In addition, the creation of some comparatively level land in the mountainous terrain of eastern Kentucky may be considered as an off-setting benefit arising from surface mining. These other possible damages and benefits are not measured herein. In addition, the lower industrial accident rate may be cited as a benefit of surface compared to underground mining; however, the difference would not correctly be included as a benefit in this analysis. These differential accident rates would appropriately be considered in an examination of the comparative costs and benefits of all sources of fuel—coal, oil, gas, nuclear, hydro, and solar.

rivers by these minerals corrodes bridge supports, increases the cost of processing water for both domestic and industrial use, kills fish, and decreases the aesthetic values of streams and lakes. Acid water originates in three different areas of a contour mining site in eastern Kentucky. These areas are labeled "A" "B" and "C" in Figure 1.

FIGURE 1  
Sources of Acid Water and Silt Pollution Where the Contour  
Method of Bituminous Coal Surface Mining is Utilized



2. Reduction of external diseconomies caused by sediment material flowing from the mining site.

Silt material is carried from the mining site by run-off water into surrounding streams and bodies of water. This sediment reduces the water-carrying ability of streams and the storage capacity of lakes and reservoirs.<sup>3</sup> The basic sources of this silt material are areas "B" and "C" in Figure 1.

3. Reduction of other external diseconomies.

Surface mining removes the vegetative cover of the land and causes

3. At the same time, it is recognized that a reduction of the water run-off rate in some tributaries may be beneficial.

some loss of aesthetic values. Owners of the land surface only may receive from the mining firms a relatively reduced amount of compensation because of the provisions of the broad form land deed.<sup>4</sup> The mining process may entail additional external charges such as damages from landslides.

### *B. Acres Disturbed by Surface Mining*

In the years prior to 1966, the land measurements submitted in surface mining permit applications were not computed according to any common standard. Such measurements were probably more accurate from 1964 than in earlier years, since commencing in this year the mining areas were surveyed by professional engineers. However, in 1966 and 1967 the acreage was determined by a standard formula promulgated by the Kentucky Reclamation Division (Kentucky Department of Natural Resources). Comments by personnel of the Division in 1968 indicate that the actual acreage disturbed by surface mining was grossly understated in permits issued in earlier years. Therefore, the acres disturbed in 1966 are used herein as a standard for the calculation of such acreage in other years. Table 1 shows the acres considered disturbed during 1962-1967 and also an example of the method of acreage calculation utilizing the 1966 permitted acreage as a standard.

### *C. Discounting of Specific External Costs*

The procedure for measuring some external costs involves the deduction of the share originating in eastern Kentucky surface mining sites from the total of such costs which arose from all bituminous coal mining in the Appalachian region. The total cost figures utilized are those estimated by the U.S. Public Health Service (references are shown in Table 2). Other costs are those contained within eastern Kentucky, such as those imposed upon land surface owners only. All costs are assigned on a per-disturbed-acre basis, and some costs are further allotted to each part of the mining site, such as acid run-off water from only the downslope of the removed overburden. Costs from all sources are summed and computed for the year of mining and future periods. Costs incurred in future years are discounted to the year of mining.

The suggested measurements include:

the external costs originating from a period's surface mining operations—this period's charges plus those of future periods;

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4. This type of land deed, used extensively in eastern Kentucky, separates the surface and the mineral rights. Several aspects of this land deed are further discussed below.

TABLE 1

Data Utilized in the Determination of Actual Acres of Land Disturbed by Bituminous Coal Surface Mining in Eastern Kentucky, 1962-1967

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year <sup>1</sup>	Average Seam Thickness Stripped <sup>2</sup> (ft)	Average Seam Thickness Augered <sup>3</sup> (ft)	Average Seam Thickness <sup>4</sup> (ft)	Tons Per Acre <sup>5</sup>	Total Surface Production <sup>6</sup>	Total Acres Disturbed <sup>7</sup>	Tons Per Acre Disturbed
1962	3.5	4.1	3.8	6,840	6,390,836	3,364	1,900
1963	3.7	4.2	3.95	7,110	6,993,194	3,541	1,975
1964	4.0	4.2	4.1	7,380	7,626,482	3,720	2,050
1965	4.3	4.3	4.3	7,740	9,587,626	4,459	2,150
1966	4.4	4.4	4.4	7,920	9,711,238	4,414	2,200
1967	4.5	4.4	4.45	8,010	11,352,004	5,102	2,225

NOTES: <sup>1</sup> Calendar years.

<sup>2</sup> and <sup>3</sup> Average seam thickness for 1965 is from U.S. Bureau of Mines Information Circular 8345, W. H. Young, *Thickness of Bituminous Coal and Lignite Seams Mined in 1965*, (August, 1967); seam thicknesses for 1962 through 1964 determined by interpolation (utilizing data for 1960 and 1965); seam thicknesses for 1966 and 1967 determined by extrapolation and estimates by mining engineer, Kentucky Department of Mines and Minerals.

<sup>4</sup> Average thickness determined by an average of the strip and auger thicknesses, since approximately one-half of eastern Kentucky surface tonnage is produced by each method of mining.

<sup>5</sup> Calculated on the basis of 1,800 tons per acre foot of coal and 100 percent recovery.

<sup>6</sup> Data from *Annual Reports* of Kentucky Department of Mines and Minerals for the period covered.

<sup>7</sup> Actual acres disturbed including coal-haul roads according to the standard used in 1966 by the Kentucky Reclamation Division. The acres newly permitted in 1966 plus the acres renewed in 1966 minus the acres renewed in 1967 equal 4,414 acres, the number considered disturbed in 1966. The total production for 1966, divided by 4,414 acres equals 2,200 tons produced for each acre disturbed. The tonnage from an acre of coal in 1966 equals 7,920 and divided by 2,200 equals 3.6 acres disturbed for each acre of coal. Using this standard of 3.6 acres, the total acres disturbed for any other year may be determined. For example, in 1963: total production of 6,993,194 tons divided by 7,110 tons equals 983.57 acres of coal; the acres of coal multiplied by the standard of 3.6 equals 3,541 acres disturbed.

changes in these external costs caused by natural forces and by land reclamation requirements.

The specific costs for the 1962-1967 period, symbolically, are:

The amount of external costs from surface mining operations in time period  $t$  caused by acid run-off water,

$A_t^c$  = from the coal face, auger holes, and breakthroughs of underground mines.

$A_t^m$  = from the mining and fill bench.

$A_t^s$  = from the downslope of the removed overburden (spoil bank).

$A_t = A_t^c + A_t^m + A_t^s$

The amount of external costs from surface mining operations in time period  $t$  caused by silt material,

$S_t^m$  = from the mining and fill bench.

$S_t^s$  = from the downslope of the removed overburden (spoil bank).

$S_t = S_t^m + S_t^s$

$B_t$  = The amount of external costs from surface mining operations in time period  $t$  caused by the loss of aesthetic values at the mining sites by the general public.

$O_t$  = The amount of external costs from surface mining operations in time period  $t$  imposed upon owners of the land surface only.

$L_t$  = The amount of external costs from surface mining operations in time period  $t$  caused by landslides. These costs are in addition to any additional acid water and silt damages caused by landslides.

The total external costs from surface mining operations in time period  $t$ ,

$$(1) E_t = A_t + S_t + B_t + O_t + L_t$$

is a product of the number of acres disturbed and the charge per acre. For example:

$N_t$  = The number of acres disturbed in period  $t$ .

$C_t$  = The dollar amount of external cost per disturbed acre from surface mining operations in time period  $t$ , caused by acid run-off water from the coal face, auger holes, and breakthroughs of underground mines.

$$(2) A_t^c = N_t C_t$$

Even if no changes in the land reclamation requirements take place, it must be recognized that nature causes some of the external costs to change over time. For example, the acids in the overburden leach out over time, fallen material from above the coal seam may gradually cover the face of the coal seam, and vegetation spreads to disturbed land from the surrounding area. Thus, the physical amount of acid pollution, for instance, may decrease over several years. Therefore,  $C_t$  must also reflect any changes in costs resulting from natural causes.

$$(3) C_t^1 = C_t^0 (a_{0t} + a_{1t} + \dots + a_{nt})$$

$$= C_t^0 \sum_{i=0}^n a_{it} \quad (n = \text{number of the year in which } a_n = 0)$$

= Total external costs per disturbed acre for acres disturbed in

period  $t$  and including costs arising in future years (but not discounted).

The value of the coefficient "a" is assigned for each time period. For example, the total costs from this source for the mining which took place in 1963 is computed by assigning the following values to the coefficients.<sup>5</sup>

$$\begin{aligned} a_0 &= 1.0 & a_2 &= .4 & a_4 &= .2 & a_6 &= 0.0 \\ a_1 &= .6 & a_3 &= .3 & a_5 &= .1 \end{aligned}$$

$$\begin{aligned} (4) C'_{1963} &= \$4.59 (1. + .6 + .4 + .3 + .2 + .1 + 0) \\ &= \$11.934 \end{aligned}$$

And where  $N_{1963} = 3,541$  acres,

$$(5) A_{1963}^c = \$42,258.29 \text{ (not discounted).}$$

The purpose of reclamation requirements is to reduce the amount of the external diseconomies; therefore, these restraints have the objective of reducing the values of the coefficients. For example, more complete coverage of the coal face and auger holes would reduce the value of "a" for each time period. In addition, the time span may be shortened and cause  $a_t$  to become zero at an earlier period.

Future costs associated with any period's coal production should be discounted to the base period. But what rate of discount should be used? If the mining firm is forced by law to incur all external costs, it could either pay these costs as they occur each year or establish a sinking fund. In the former case the future costs should correctly be discounted at a rate appropriate for a mining firm. The U.S. Department of Interior recommends a rate of twelve percent to represent mineral industry expectations for normal risk undertakings.<sup>6</sup> The use of this rate would assume that the firm earns twelve percent on its funds and pays the external costs in each future period. The second possibility would assume that the firm establishes in the period of mining a sinking fund of a sufficient amount to cover all future costs. If such a fund is invested in Government bonds, for example, the appropriate discount rate should be utilized.

5. The values of the coefficients and the time spans were determined in consultation with personnel of the Kentucky Reclamation Division, Kentucky Reclamation Association, Water Resource Center, Indiana University, and others.

6. U.S. Bureau of Mines, Div. of Economic Analysis, Economic Advice No. 15, Economic Valuation of Mineral Resources (1968).



An alternative to these two methods of calculating the present value of future costs is to assume that each other firm or segment of society incurring these external charges has its own discount rate. The present value of future charges would then be calculated using a multitude of discount rates. Thus, firm "A" which incurs certain costs due to acid water pollution would be reimbursed an amount in the year of mining to cover all of its future costs from this source of pollution. In this case, the present value of these future costs would be discounted at the rate appropriate for firm "A" and not the mining firm. An additional alternative would be that the mining firm would place funds in some other economic endeavor which would return more than twelve percent. In this case, the external charges would be discounted at this higher rate. However, we must assume that the mining of coal represents the best opportunity available to the firm for the investment of its funds, otherwise, it would be engaged in the other economic activity with the higher return.

The intent of the Kentucky reclamation law and regulations is to reduce or eliminate these external charges by prescribing certain land reclamation, rather than by requiring direct reimbursement to other parties or public agencies. However, either method would minimize losses of these external parties. Reimbursement may be considered as the estimated maximum net cost chargeable to the mining firm. Therefore, the rate of twelve percent is considered appropriate for the calculation of the present value of future costs.

Equation (5) must therefore be extended to include the discounting of future costs.

$$\begin{aligned}
 & r = \text{discount rate.} \\
 (6) \quad C_t &= C_t^0 \sum_{i=0}^n \frac{a_{it}}{(1+r)^i} \\
 &= C_t' \text{ discounted.}
 \end{aligned}$$

Thus, the present value of the total external cost from Source A<sup>c</sup> arising from the 1963 surface mining operations, where  $r=12$  percent,

$$C_{1963} = \$10.336$$

$A_{1963}^c = \$36,599.78$  (Instead of the undiscounted amount of \$42,258.29.)

## II EXTERNAL COSTS

### A. Source A—Acid Run-Off Water

Table 2 depicts the data for the computation of the external costs arising from this type of water pollution. The cost of \$11.466 per

TABLE 2  
Data Utilized in the Determination of Total External Costs Arising From Acid Mine Run-off Water From Eastern Kentucky Bituminous Coal Surface Mining: 1962-1967

When the Base Year (t) is:	Cost Per Acre Disturbed (Present Value in Base Year)	The Time Periods The Value of the Coefficients Dollar Value Discounted to Base Year at 12 percent							
		a <sub>0</sub>	a <sub>1</sub>	a <sub>2</sub>	a <sub>3</sub>	a <sub>4</sub>	a <sub>5</sub>	a <sub>6</sub>	a <sub>7</sub>
For A <sup>c</sup> (From Coal Face, Auger Holes, and Breakthroughs)									
1962 and 1963	\$10.336	1.	.6	.4	.3	.2	.1	0	—
1964 and 1965	5.410	1.	2.459	1.464	0.980	0.583	0.260	0.000	—
1966 and 1967	2.295	.5	.820	0.000	0.000	0.000	0.000	0.000	—
For A <sup>m</sup> (From Mining Bench)									
1962 and 1963	4.921	1.	.7	.4	.2	.1	0	0.000	—
1964 and 1965	3.291	1.	1.429	0.730	0.326	0.146	0.000	0.000	—
1966 and 1967	1.914	.7	.4	0.183	0.000	0.000	0.000	0.000	—
For A <sup>s</sup> (From Downslope)									
1962 and 1963	13.274	1.	.8	.6	.5	.3	.1	.1	.1
1964 through 1967	10.494	1.	3.279	2.195	1.634	0.875	0.260	0.233	0.208

SOURCES: The total costs imposed upon society in 1960 from acid mine water from the Appalachian Region was stated to be \$9,570,000 by the U.S. Public Health Service, *Water Pollution Control and Abatement*, Hearings before a Sub-Committee of the Committee on Government Operations, House of Representatives, 88th Congress, 1st session (1964). Twenty-five percent of such damage comes from surface mining in Appalachia (\$2,392,500) and Eastern Kentucky contained 6.976 percent of such mining in this region. In 1960 there were the equivalent of 14,556 acres newly surface mined in Eastern Kentucky. This equals \$11,466 per disturbed acre (data for 1960 and 1961 not shown above). It is estimated that 2/5 of acid run-off water originates from the coal face and auger holes, 2/5 from the downslope, and 1/5 from the mining bench. The values of the coefficients, time spans, and proportions were determined in consultation with personnel of the Kentucky Reclamation Division (Kentucky Department of Natural Resources), Kentucky Reclamation Association, Water Resources Center, (Indiana University), and members of the industry.

acre disturbed was derived from data presented by the U.S. Public Health Service.<sup>7</sup> (The data are for 1960 and are utilized to determine the costs for each year during the 1960-1963 period—only the two years of 1962-1963 are shown in Table 2.)

The cost of acid mine water damages per disturbed acre of surface mined land in eastern Kentucky is calculated as follows. Only 25 percent of acid mine water originates at the surface mining operations; the remaining 75 percent arises from underground mining. Data presented by the U.S. Department of Interior<sup>8</sup> indicate that approximately seven percent of the surface mining in Appalachia took place in eastern Kentucky in 1960. Considering the number of acres newly surface mined in that year, plus such acreage in the preceding ten years, it is estimated that the equivalent of 14,556 acres were newly surface mined in eastern Kentucky in 1960. The amount of damage from acid water drainage thus equals \$11.466 per newly disturbed acre.

This cost was incurred during each year of the 1962-1963 period when relatively little reclamation was accomplished. Two-fifths (\$4.59) of this per acre cost is considered to arise from Source A<sup>c</sup> (coal face, auger holes, and breakthroughs of underground mines); one-fifth (\$2.29) from Source A<sup>m</sup> (the mining bench); and two-fifths (\$4.59) from Source A<sup>s</sup> (the downslope of the removed overburden).

### 1. Source A<sup>c</sup>

During the 1962-1963 period the Kentucky reclamation law and regulations required coverage of the coal face and auger holes, and the sealing of breakthroughs. This work was not always accomplished, due to lax enforcement by the state agency. Nevertheless, partial coverage after mining, plus fallen material from above the seam, are considered sufficient to have caused a decrease and final halt of the flow of acid water from this source over the following six

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7. *Water Pollution Control and Abatement*, Hearings Before a Subcomm. of the House Comm. on Government Operations, 88th Cong., 1st Sess. (1964). The annual damages from acid mine water from the Appalachian Region for 1960 was estimated to be \$9,570,000 by this Government agency. This estimate includes damages to: domestic water supplies, industrial water supplies, steamboats and barges, power plants, river and harbor structures, and floating plant, all damages occurring in the smaller streams in Appalachia, and the loss of aesthetic values in the area. While this estimate is a projection of a survey made in 1940, Tybout, in *An Economic Framework for Evaluation of Acid Mine Drainage*, Water Quality and Recreation in Ohio, Proceedings, Second Annual Symposium on Water Resources Research 229 (1966), states that these damages are "... probably as great today," and further that, "... the overall magnitudes cannot have changed radically except for steamboats downward and probably for power plants upward. The suggestion on the basis of information now available is that the total magnitude of the problem remains similar now to what it was in 1940," *id.* at 232.

8. U.S. Dep't of Interior, *Study of Strip and Surface Mining in Appalachia* 23-24 (1966).

years. This decrease is indicated in Table 2 by the decline in the values assigned to the coefficients over the six-year period ( $a_0$  through  $a_5$ ). In 1964-1965, the coverage of the coal seam and auger holes was extended to two feet above the seam. Enforcement of this requirement halted the flow of this acid water in the second year after mining. In 1966-1967, coverage of the coal seam was further heightened to four feet above the seam. In addition, a shortening of the time period between coal removal and the accomplishment of this reclamation requirement gave rise to relatively less pollution from this source during the period of mining. Thus, the coefficient  $a_{0t}$  is reduced to 0.5 when  $t$  is 1966 and 1967 (Table 2).

### 2. Source A<sup>m</sup>

In the 1962-1963 period, little regrading of the mining bench was required, coverage of acid producing materials was not effectively enforced, and a minimum of revegetation was accomplished. Water pollution from this source is considered to have continued for an average of five years, but in declining amounts (Table 2). Normal leaching of the soil plus some natural re-seeding of vegetation from surrounding areas caused such a decline. Regrading of material across the mining bench in 1964-1965, plus additional revegetation and coverage of toxic materials reduced the flow of acid water from the mining bench. This reduction is reflected in the values of the coefficients assigned this origin. A further reduction of water pollution originating at this source was accomplished in 1966-1967 by additional grading and revegetation. A shortening of the time span for the performance of reclamation is reflected in the decrease in the coefficient value for the period of mining,  $a_{0t}$  from 1.0 to 0.7 when  $t$  is 1966 and 1967.

### 3. Source A<sup>s</sup>

The flow of acid water from the downslope continues for a longer time than from the above two areas. While natural leaching also takes place on the downslopes, some sliding of the material down the hillside exposes new material. The grading of some of this overburden across the mining bench reduced the pollution from this source commencing in 1964. Although additional grading and revegetation was required in 1966, no reduction of acid water flow occurred in this year. As a result of the bench-width restrictions imposed in 1966, mining firms merely stacked the overburden higher causing no net change in the amount of water pollution from this source (Table 2).

The total external costs arising from the three sources of acid

run-off water from surface mining for the 1962-1967 period are shown in Table 3 together with other external costs. It is noted here, however, that the total of these costs decreased from about \$96,000 in 1962 to about \$75,000 in 1967, (or about 22 percent) although the number of acres disturbed by surface mining increased approximately 52 percent over the same period.

### *B. Source S—Silt and Sediment Materials*

Surface mining in the steeply-sloping terrain in eastern Kentucky causes severe erosion of the soil material removed throughout the course of the mining process. During periods of heavy rainfall this material flows from the mining site into streams and other bodies of water. The water-carrying capacity of these streams is decreased and the storage capacities of lakes and reservoirs are reduced. On the basis of the U.S. Forest Service experiment in eastern Kentucky, the U.S. Department of Interior estimates that approximately 400 tons of soil per acre of newly disturbed overburden flow into streams and other bodies of water. This quantity compares to about one ton of material from the same area prior to disturbance by surface mining.<sup>9</sup>

The external cost imposed upon other parties or society in general from this silt and sediment material is calculated herein on the basis of the cost to remove such material from streams, lakes and reservoirs. A cost of \$0.07 per ton is used as an estimated average for the removal of this material.<sup>10</sup> The spoil bank settles over time and becomes relatively more stable. This process reduces the amount of material flowing from the disturbed area. In addition, this reduction is accelerated by grading of the mining bench and by revegetation of the disturbed area. (Space does not permit the inclusion of the data used to calculate the total external costs caused by silt and sediment material from mining operations; i.e., data such as that in Table 2 for acid mine run-off water.)

The total annual cost imposed upon other parties by silt and sediment material, originating on the mining bench fell from about \$37,000 to \$26,000 between 1962 and 1967, although the number

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#### 9. *Id.*

10. During the first year, an estimated 400 tons of silt and sediment flow from each acre of mined bench and spoil bank combined. The downslope of the spoil bank contributes 300 tons and the mined bench 100 tons. The downslope comprises 1/3 and the mined bench 2/3 of each acre. For each acre mined, 3.6 acres are disturbed. For each 3.6 acres disturbed, there are 2 acres of mined bench and 1 acre of downslope. For each two acres of mined bench 300 tons of material flow, or 83.33 tons per acre disturbed. For each 1 acre of downslope 900 tons flow, or 250 tons per acre disturbed. The removal of silt and sediment material from streams, rivers, lakes, and reservoirs is estimated to cost an average of \$0.10 per cubic yard of material. This material weighs an average of 105 pounds per cubic foot, or 2,835 pounds per cubic yard. Cost of removal equals approximately \$0.07 per ton.

TABLE 3  
Total External Costs Arising from Bituminous Coal Surface Mining in Eastern Kentucky From All Sources, 1962-1967

Year	Sources of External Costs										Total Cost	Per Acre Disturbed	Per Ton Mined
	A <sub>t</sub> <sup>c</sup>	A <sub>t</sub> <sup>m</sup>	A <sub>t</sub> <sup>s</sup>	A <sub>t</sub> <sup>m</sup>	S <sub>t</sub> <sup>s</sup>	B <sub>t</sub>	O <sub>t</sub>	L <sub>t</sub>	S <sub>t</sub> <sup>s</sup>	S <sub>t</sub> <sup>m</sup>			
1962	\$34,770	\$16,554	\$44,654	\$37,115	\$164,698	\$3,364	\$3,000	\$4,450	\$308,605	\$91.74	\$0.048		
1963	36,600	17,425	47,003	39,068	173,364	3,541	5,000	4,700	326,701	92.26	0.047		
1964	20,125	12,243	39,038	34,451	143,644	2,790	6,000	4,900	263,191	70.75	0.035		
1965	24,123	14,675	46,793	41,295	172,180	3,344	7,000	5,900	315,310	70.71	0.033		
1966	10,130	8,448	46,321	22,617	170,442	3,311	3,000	5,850	270,119	61.20	0.028		
1967	11,709	9,765	53,540	26,143	197,009	3,827	3,000	6,750	311,743	61.10	0.027		

SOURCES: Totals of each source of external costs are from data presented in the text. Annual tonnages for computation of cost per ton mined are from *Annual Reports*, Kentucky Department of Mines and Minerals, for period covered.

of acres disturbed increased about one-half. The annual external cost of the material flowing from the downslope, however, rose from about \$165,000 to \$197,000 during this six-year period. While some additional grading of the mining bench and revegetation were required starting in 1966, total bench-width restrictions induced mining firms to stack the overburden higher. The reclamation requirements imposed upon the surface mining firms were relatively more effective in reducing external costs due to the silt and sediment material given off from the mining bench than from the downslope of the removed overburden. These costs are shown with other external charges in Table 3.

### *C. Source B—Loss of Aesthetic Values*

The U.S. Public Health Service included the loss of aesthetic values in its valuation of total losses from acid mine water. The external costs from the silt and sediment material in streams and bodies of water include the associated aesthetic values. These two costs have been considered above. The aesthetic values of the land surface lost during mining incurred by the land surface owner is considered below. However, it may be claimed that the general public also suffers a loss when the scenic values of the nation's countryside are destroyed.

The hills of eastern Kentucky are covered with a growth of trees and other vegetation which most people would consider beautiful. This beauty is disturbed and interrupted by the strips of bare earth and rock exposed by surface mining. The exposure is greater where more than one coal seam is mined along the contour of the hills. Here, the overburden from one mining shelf flows downward and contacts the area exposed by mining operations at the lower altitude. Comparatively larger areas are denuded of vegetation when the entire upper portions of hills are removed during the mining process.

It is reasonable to assume that the general public is somewhat affected by the environment, and therefore recognition should be made of the loss of aesthetic values caused by surface mining in eastern Kentucky. Such a recognition is considered appropriate, since the reclamation requirements have reduced this loss. This charge upon society, however, must be valued at a relatively low level. Eastern Kentucky is not thickly populated, and is comparatively isolated from the surrounding areas. A higher value would appropriately be assigned to aesthetics in thickly populated regions.

For the 1962-1963 period, the loss of aesthetic values at the mining site by the general public is assigned a value of \$1.00 per acre disturbed. This amount is considered to include the loss during the

year of mining and all future years discounted at the rate of twelve percent. The regrading and comprehensive revegetation requirements of the mined areas were commenced in 1964. This action not only ensured that more of the mined areas would be revegetated, but also shortened the time span necessary for relatively more complete coverage. Therefore, the loss of aesthetic values at the mining site is valued at \$0.75 per disturbed acre for the 1964-1967 period. The annual totals of this external cost are combined with other external costs in Table 3 (Source B).

#### *D. Source O—Losses Incurred By Owners of the Land Surface Only*

Eastern Kentucky mineral rights were sold in the late 1800's and early 1900's by the landowners when surface mining methods were unknown. The broad form deed was used for the transference of these rights, and conveys all the coal and,

... the privilege to use and operate the surface in any and every manner that may be deemed necessary or convenient for mining, and therefrom removing ... and in the use of said land and surface thereof by the grantee shall be released from liability for damages.<sup>11</sup>

The separation of the land surface and mineral rights does not occur in all states. For example, in Indiana and Illinois a landowner may lease to a mining firm the right to exploit the minerals, but this lease or sale does not separate the mineral rights in perpetuity from the surface rights. Incidences of personal hardship involving some surface mining also are unique to eastern Kentucky; some cases of personal distress have occurred solely as a result of these separate ownerships. Some situations involving personal hardships are recounted by Harry M. Caudill.<sup>12</sup> At the same time, it must be noted that not all eastern Kentucky land has separate owners of the mineral and surface rights. The annual proportion of total disturbed land represented by acreage with separate owners has varied from about one-fourth to one-half during this six-year period.

Approximately 97 percent of all acres surface mined during 1962-1967 was disturbed by mining firms which had leased this right from the minerals owner who received a royalty for each ton of coal

11. U.S. Dep't of the Interior, *Surface Mining and Our Environment* 103 (1967).

12. H. Caudill, *Night Comes to the Cumberlands* (1962). In addition, some protests by owners of the surface only were voiced in connection with the passage of the 1966 revisions in the Kentucky reclamation law. Although some of this dissent against surface mining was made in response to damage or the threat of damage to the surface owner's property, a share of these remonstrances was made on other grounds. The mountaineer of eastern Kentucky has for generations feared and distrusted the outsider. The surface mining firm is considered an intruder.



extracted. If this owner also owned the surface rights, i.e., fee ownership, he also incurred the cost of any damage to the land surface—destruction of trees and loss of aesthetic values. Therefore, rational calculation by the owner would have included this cost in the royalty payments for which he contracted.

However, when the land has separate owners of the minerals and surface rights, the coal royalty is paid only to the mineral rights owner. In addition, if other factors are equal—coal quality, type and depth of overburden, transport costs—the royalty is equal to that paid to an owner of the land in fee. Thus, in this latter case, the owner of the surface does not share in the coal royalty. It would therefore appear that this surface owner receives no compensation for any damages caused by surface mining.

Nevertheless, eastern Kentucky surface mining firms leasing mineral rights on land with separate ownerships do pay the surface owners an “access fee.” This payment is approximately \$0.25 per linear foot of land as measured along the highwall of the contour mining site. The amount per ton of coal varies widely, of course, depending upon the width and thickness of the coal seam strip mined and whether the auger method is also employed. While the owner of the surface rights only is somewhat compensated for damages to the surface, he lacks the necessary bargaining power to receive any economic rent which may be due because of the location of his land. Nevertheless, this access fee payment is considered to fully cover the surface owner’s costs of temporary loss of the land use and the decrease in aesthetic values.

At the same time, the surface owners have clearly had some imposed external costs caused by the removal of the overburden; for example, large rocks rolling down the hillsides. Such damages have been associated with the operations of a minority of the mining firms. Personnel of the Kentucky Reclamation Division indicate that no more than 10 or 12 situations involving such damages occurred in the two years prior to 1966, and only about one-third as many since the law’s newest revision became effective.

In 1964 and 1965 the disturbed acres with separate ownerships totaled 3,461. Assuming 12 cases of property damage during these two years, one damaging instance occurred per 288 acres (or fraction thereof) of disturbed land with separate ownerships. Estimated damages are \$1,000 per case. We may apply this ratio of loss cases to acres disturbed in the years prior to 1964. However, due to the authority of the Reclamation Division to prohibit mining in areas where possible damage may result from such operations, the ratio for

1966 and 1967 is changed to one loss of \$1,000 per 864 acres (or fraction thereof). The annual totals of this external cost imposed upon these surface owners are indicated in Table 3 (Source O).

### *E. Source L—Losses Caused by Landslides*

The sudden movement of portions of the spoil bank down the hillside in the form of landslides causes several types of damage. Some of these costs are already included in the previously calculated external charges. For example, the costs caused by acid water and silt and sediment materials include the additional amounts of such damages brought about by landslides. In addition, the loss of aesthetic values at the mining site—landslides increase the barren area and inhibit the growth of vegetation—and the costs imposed upon surface owners include estimated charges arising from landslides.

Landslides, however, impose other costs upon society. In addition to increasing the flow of silt material from the mining area, a landslide itself may block or disrupt the water flow in a stream; the sliding material may cover a public road or highway. A comparatively massive landslide damages several acres of land below the mining area. At the same time, we must recognize that some landslides cause relatively little damage. The sudden sliding of removed overburden down the hillside in an isolated, uninhabited region may merely mean that the material now covers an additional acre of comparatively valueless undergrowth and scrub timber.

The Kentucky Reclamation Division reported in December, 1967, that approximately 135 landslides had occurred over the previous 12-month period.<sup>13</sup> Discussions with personnel of the Division concerning the cost of damages caused by landslides revealed that such costs are among the more difficult costs to estimate. As noted above, the locations and size of landslides are diverse. The estimated cost of the damage from a landslide may vary from almost nil to several hundred dollars. However, utilizing the data reported by the Division, approximately one slide occurred per 38 acres of disturbed land; and further, we may reasonably estimate an average damage cost of \$50 per slide. The annual estimated totals of this external cost are shown in Table 3 (Source L).

### *F. Total External Costs*

While the total external costs per acre disturbed decreased over this six-year period—from about \$91.74 to \$61.10—the aggregate external charges for eastern Kentucky rose from about \$308,605 to

13. Hearings on New Reclamation Regulations in Kentucky, held in Frankfort, Kentucky, on Dec. 7, 1967 (unpublished transcript).

\$311,743 (Table 3). The annual acreage disturbed by surface mining increased over this same period from 3,364 to 5,102 acres. Thus, an approximate 52 percent increase in annually disturbed acreage was associated with only about a one percent rise in the annual external costs arising from such mining. Relatively more comprehensive and effectively enforced land reclamation brought about this comparatively lower increase in aggregate external charges.<sup>14</sup>

Although the total annual eastern Kentucky surface-mined tonnage rose from 6,390,826 to 11,352,004 tons, or about 78 percent, over this six-year period, the total external costs per-ton-mined decreased from about \$0.048 to \$0.027 per ton, or about 44 percent, over the same period (Table 3). This decline in total external costs per ton of coal produced may be attributed to two factors. First, increased land reclamation requirements were instituted and enforced over this period; and second, the average number of tons mined per acre disturbed increased. The latter increase was due to a rise in the average thickness of the coal seams exploited by strip and auger mining methods in eastern Kentucky from 3.8 to 4.45 feet between 1962 and 1967. Therefore, even without changes in the extent of land reclamation, the external costs per-ton-mined decreased annually. But, the increases in the amount of land reclamation in the years of 1964 and 1966 accelerated this decline.

### III INTERNAL EXPENSES

Increases in the amount of land reclamation performed by the bituminous coal surface mining firms during 1962-1967 caused an increase in internal mining expenses. Such charges are divided into two components for the purpose of this survey, i.e., enforcement expenses and direct land reclamation expenses. The former category includes: state permit and acreage fees, court fines, performance bond fees, and other charges (land survey, map, and administrative expenses). None of these expenses contribute directly to land recla-

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14. Two limitations of this analysis must be recognized here. First, the external costs shown in this examination are those arising from bituminous coal surface mining only in eastern Kentucky during the period surveyed. The external costs originating from the contour mining operations in adjacent regions, for example, would be different due to dissimilar definitions of "acres disturbed" and to the relative extent of surface mining in these other areas. Similar mining operations would probably impose comparatively higher external costs upon society in a more densely populated region. Second, the amount of any external charge is not considered to be exact. While some of these charges are based on the best considerations and projections of professional personnel and government agencies, these costs remain estimates—other appraisals are possible. Nevertheless, the relative magnitudes of the various external costs and internal expenses would not be substantially changed by other reasonable assessments of these charges.

mation. The second category, direct land reclamation expenses, includes those expenses associated with earth movement, revegetation of the mined area, and the construction of drainage ditches.

#### A. Enforcement Expenses

The total expenses to the mining firms to obtain a permit to surface mine bituminous coal in eastern Kentucky are indicated in Table 4. The permit and acreage fees, and court fines for violations of regulations are paid directly to the Kentucky Reclamation Division for its use in enforcing the law and regulations.

TABLE 4  
Total Enforcement Expenses of The Kentucky Reclamation Law and Regulations  
Associated With Eastern Kentucky Bituminous Coal Surface Mining Incurred by  
The Mining Firms; 1962-1967

Year	Permit Fees	Acreage Fees	Court Fines	Performance Bond Fees	Map, Land Survey and Other Expenses	Total	Total Average Expenses Per Disturbed Acre
1962	\$4,830	\$20,950	—	\$ 2,556	\$ 815	\$ 29,151	\$ 8.67
1963	4,140	22,245	—	2,580	690	29,655	8.37
1964	6,960	53,815	\$3,450	4,255	3,480	71,960	19.34
1965	9,810	109,075	2,375	10,038	4,905	136,203	30.55
1966	14,080	110,350	2,400	14,170	8,750	149,750	33.93
1967	22,750	127,550	9,190	20,903	11,375	191,768	37.59

SOURCES: Kentucky Reclamation Division files and regulations, and estimates made in consultation with members of the industry.

NOTES: Cost of permits is average of \$30 per permit for 1962 through June, 1966, and \$50 thereafter.

Performance Bond Fee is \$12.50 per \$1,000 bond, per year, Map, Land Survey, and Other Costs computed at following rates: 1962-1963, \$5. per permit; 1964-1965, \$15. per permit; and 1966-1967, \$25. per permit.

Performance bond fees are paid to private bonding companies. The applicable fee—\$12.50 per \$1,000 bond per year—is regulated by the State of Kentucky. The estimated average expenses incurred by the mining firms to survey the mining site, to prepare and submit the required map, and other administrative expenses associated with a permit application are based on information obtained from members of the industry and the Reclamation Division. While the permitted acreage increased by about one-half between 1962 and 1967, the 1967 average enforcement expense per acre to the firm was over four times this expense in 1962. This rise is attributed to an increase in the acreage fee over this six-year period—from \$10 to \$25 per acre—and to an increase in the required performance bond per permitted acre—from \$100 to \$200 (minimum bond of \$2,000 is required per permit).

## B. Direct Land Reclamation Expenses

### 1. Regrading

During the 1962-1963 period relatively little regrading of the surface mined land was required and performed. Some earth movement was accomplished to cover the coal seam face and to bury toxic materials. However, a sizeable increase in the expenses of regrading, burying of toxic materials, and the construction of drainage ditches occurred in the 1964-1965 period. Additional coverage of the coal seam, plus the grading of some removed overburden back toward the highwall, caused an increase in both labor and machinery time. Since grading does not take place on the downslope of the removed overburden, all acres disturbed are not graded. For each 3.6 acres disturbed, only approximately two acres are actually graded. An estimated seven actual acres could be graded in eight hours during this 1964-1965 period at an average expense of \$18 per hour for labor and machinery. However, the number of acres regraded in the 1966-67 period in eight hours was reduced from an average of seven to five actual acres. This decrease was due mainly to the requirement to cover the mining bench with at least four feet of material from the removed overburden. From 1962 to 1967 these expenses rose from an average of \$2 per acre disturbed to \$16 as shown in Figure 2.

Figure 2

Data Utilized to Compute Direct Land Reclamation Expenses Associated with Eastern Kentucky Bituminous Coal Surface Mining, 1962-1967.

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#### *Required Grading, Burying of Toxic Materials and Drainage Ditches.*

##### *Period*

1962-1963—\$2.00 per acre disturbed.

1964-1965—\$11.43 per acre disturbed. (Required work on 7 actual acres completed in 8 hours, at \$18. per hour, equals \$20.56 per actual acre. Two actual acres graded, etc. per 3.6 disturbed acres).

1966-1967—\$16.00 per acre disturbed. (Required work on 5 actual acres completed in 8 hours, at \$18. per hour, equals \$28.80 per actual acre. Two actual acres graded, etc. per 3.6 disturbed acres).

##### *Revegetation*

1962-1963—\$15.00 per acre disturbed. (\$18. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

1964-1965—\$25.00 per acre disturbed. (\$30. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

1966-1967—\$30.83 per acre disturbed. (\$37. per actual acre revegetated; three acres planted per 3.6 disturbed acres).

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SOURCES: Estimates based on consultations with members of the industry, Kentucky Reclamation Division (Department of Natural Resources), and representatives of the Kentucky Reclamation Association which performs revegetation of mined areas.

## 2. Revegetation

The revegetation of surface mined land during the 1962-1963 period involved an estimated expense of approximately \$18 per acre planted. Since only three acres are planted per 3.6 acres disturbed, this involved an average expense of \$15 per acre disturbed. Increases in revegetation requirements—planting and survival standards—caused a rise in this external expense over the 1962-1967 period.

The total average internal expense to the mining firms to perform the required direct land reclamation rose from \$17 in 1962 to about \$46.83 in 1967 per disturbed acre. These figures are set out in Table 5. During this six-year period the primary cause of the increase in

TABLE 5  
Total Internal Expenses of the Eastern Kentucky Bituminous Coal Surface Mining Firms  
Incurred in Performing Land Reclamation; 1962-1967.

Year	Enforcement Expense Per Acre Disturbed	Percent of Total	Land Reclamation Expense Per Acre Disturbed	Total Per Acre Disturbed	Eastern Kentucky Annual Total	Total Expenses Per Ton Mined
1962	\$ 8.67	34	\$17.00	\$25.67	\$ 86,354	\$0.014
1963	8.37	33	17.00	25.37	89,835	0.013
1964	19.34	35	36.43	55.77	207,464	0.027
1965	30.55	46	36.43	66.98	298,664	0.031
1966	33.93	42	46.83	80.76	356,475	0.037
1967	37.59	45	46.83	84.42	430,711	0.038

SOURCES: Kentucky Department of Natural Resources, and members of the industry. Annual production from the *Annual Reports*, Kentucky Department of Mines and Minerals.

land reclamation expense per disturbed acre was the 8-fold increase in grading expenses—from \$2 to \$16. Revegetation expenses per disturbed acre approximately doubled between 1962 and 1967—from \$15 to about \$30.83 (Figure 2).

### C. Total Internal Reclamation Expenses of the Mining Firms

The total average internal expenses (enforcement fees and direct land reclamation expenses) rose from about \$25.67 to \$84.42 per acre disturbed between 1962 and 1967 (Table 5). During the same six-year period enforcement expenses comprised an increasing proportion of total average expenses per acre disturbed; rising from 34 to 45 percent. The total average expense per ton mined increased approximately 171 percent—from \$0.014 in 1962 to \$0.038 in 1967.

#### IV CONCLUSIONS

##### *A. External Costs and Internal Expenses Compared*

Although the additional constraints contained in the 1964 and 1966 revisions of the Kentucky land reclamation statute and in the enforcement agency's regulations caused significant reductions in the amount of external costs imposed upon society, these decreases in external diseconomies were achieved only by larger internal expense increases, as shown in Table 6.

TABLE 6

Summary of Average Total External Costs and Internal Expenses Associated with Eastern Kentucky Bituminous Coal Surface Mining and Land Reclamation; Average Cost Per Acre Disturbed and Per Ton Mined; 1962-1967.

Period	EXTERNAL COSTS			
	Average Total Per Acre Disturbed	Average Change From Previous Periods	Average Total Per Ton Mined	Average Change From Previous Period
1962-63	\$92		\$0.047	
1964-65	71	- \$21	0.034	- \$0.013
1966-67	61	- 10	0.028	- 0.006
	TOTAL INTERNAL EXPENSES			
1962-63	26		0.013	
1964-65	62	+ 36	0.029	+ 0.016
1966-67	83	+ 21	0.037	+ 0.008
	ENFORCEMENT EXPENSES ONLY			
1962-63	9		0.004	
1964-65	25	+ 16	0.012	+ 0.008
1966-67	36	+ 11	0.016	+ 0.004

SOURCES: Summary of data appearing in other tables and in the text.

NOTE: All per acre costs rounded to the nearest dollar.

The external costs were reduced during 1964-1965 (compared to the 1962-1963 period) \$21 per acre disturbed; however, the mining firms' average internal expense of land reclamation rose \$36 in the same period. Similarly, a further average decrease of \$10 per disturbed acre was achieved in the 1966-1967 period; this decline, however, added an average of \$21 per disturbed acre to the firms' internal expenses. On a per-ton-mined basis, much the same relationship exists between the reduction of external costs and the increases of internal expenses. The latter exceeds the former charges.

The shares of the increases in total internal expenses represented by the rises in average enforcement expenses per disturbed acre are also indicated in Table 6. In the 1964-1965 period, for example,

enforcement expenses comprised \$16 of the total \$36 rise of internal expenses. Without the enforcement expenses, the \$21 decline in average external costs per acre disturbed would be associated with an increase of only \$20 of internal expenses. Similarly, in the 1966-1967 period, without the \$11 increase in average enforcement expenses per acre disturbed, the average \$10 drop in external charges would be associated with an average \$10 rise in internal expenses.

The amount of reduction in external costs, per acre disturbed, per dollar of increase in internal expenses during 1964-1965 amounted to only \$0.583 and \$0.476 in 1966-1967. Such a reduction, per ton mined, per one cent of increase in internal expenses, amounted to \$0.0081 in 1964-1965 and to \$0.0075 in 1966-1967. Therefore, additional internal expenses caused by the increases in reclamation requirements in eastern Kentucky have reduced external costs, but at a declining rate.<sup>15</sup>

While only the approximate amount of the increases of internal expenses represented by actual land reclamation costs (without enforcement charges) contributed to the associated decreases in external costs, eastern Kentucky surface mining firms could not be expected to perform the land reclamation without compulsions. Therefore, the expenses of enforcement cannot be avoided.<sup>16</sup> However, if the mining forms would have voluntarily performed the land reclamation, each dollar of the increase in internal expenses would have reduced external costs by approximately one dollar (per acre disturbed). This result, of course, raises the question of the desirability of requiring additional land reclamation. Except as

15. These conclusions may be reversed, of course, if one assigns higher values to the loss of aesthetic values. The assigned values are 1962-63: \$1; and 1964-67: \$0.75 per disturbed acre. Suppose, however, that the loss of aesthetic values per disturbed acre were designated as follows: 1962-63: \$37; 1964-65: \$21; and for 1966-67: \$9. In this case, the average total of *all* costs per disturbed acre would increase to \$128 for 1962-63; \$91 for 1964-65; and \$69 for 1966-67. With these valuations a \$37 decrease in external diseconomies would be associated with a \$36 increase in internal expenses between the 1962-63 and the 1964-65 periods. Similarly, a decrease of \$22 would be associated with an increase of such expenses of \$21 between the 1964-65 and the 1966-67 periods. In like manner, the conclusions on a per-ton-mined basis would also be reversed with these higher valuations of aesthetic losses. Such increases, however, also involve the assumptions that the loss of aesthetic values in the 1962-63 period increase from approximately one to 29 percent of the total of all social costs per disturbed acre; in the 1964-65 period an increase from about one to 23 percent; and in the 1966-67 period from about one to 13 percent. However, these proportions and dollar quantities which would be required to reverse the conclusions are deemed to be unrealistic in the present case of eastern Kentucky.

16. We may assume, however, that not all enforcement expenses are utilized for this purpose. The Kentucky Reclamation Division expends some funds for research connected with eastern Kentucky surface mining. Such research includes experiments concerning the growth and survival of various species of trees and other vegetative cover in different types of soil. Thus, perhaps a small share of the firms' internal expense increases should be considered research and development expenses instead of land reclamation expenses.



recommended in the following section, a solution for this dilemma will not be suggested here.

## RECOMMENDATIONS

### *A. The State of Kentucky*

Since the 1964 and 1966 revisions of the Kentucky bituminous coal surface mining reclamation law and regulations have caused greater increases in the mining firms' internal expenses than the decreases in external costs imposed upon society, the Kentucky General Assembly should carefully evaluate the present as well as any proposed additional land reclamation requirements applicable to such mining.

The Kentucky General Assembly might well turn its attention to other sources of external costs imposed upon society. For example, approximately 75 percent of the total acid water pollution originates from underground mining operations. Silt and sediment materials also flow from roads leading to these mines. Extensive erosion of the hillsides takes place where trees have been harvested. Legislation directed to reduce the external diseconomies originating from these sources could properly be considered.

### *B. Other Government Bodies*

The experience of the State of Kentucky not only in enacting but enforcing more comprehensive surface-mined land reclamation requirements may influence the actions of other government bodies. Indeed, this may have already occurred. For example, such a law first became effective in late 1967 in the State of Tennessee. The existing statute in the State of Indiana was revised the same year. In addition, the U. S. Senate Interior Committee held hearings in June, 1968, on a proposed Federal land reclamation law. We may ask, however, whether the actions of the State of Kentucky should be followed.

But to evaluate the Kentucky experience, several guidelines are required for the particular actions to be followed by a government body in connection with the enactment of land reclamation provisions. Such actions should be based upon:

1. Recognition of the existence of external costs arising from the surface mining process.
2. Measurement of external costs.
3. Formulation of recommended procedures and regulations to internalize such costs within the industry, including estimation of necessary internal expenses.

4. Revision of recommended land reclamation requirements if internal expense increases exceed external cost reductions.
5. Institution of land reclamation requirements.
6. Measurement and comparison of actual cost increases and decreases after a trial period.
7. Further revisions of the land reclamation requirements.

The record of the Kentucky experience indicates that four of these seven items were considered; specifically,

1. Recognition by the State of certain external costs arising from surface mining was first made in 1954 when the original land reclamation statute was enacted.
3. Following the enactment of the original statute, the State formulated some procedures and regulations to require land reclamation following the surface mining of bituminous coal. Estimates of the internal expenses to perform the land reclamation were made upon the occasion of each revision of the state law. The projections by the Kentucky Reclamation Commission differed, however, from such industry estimates. For example, in 1964 the former projected costs of 5 to 10 cents per ton mined; the latter estimated costs of 60 to 90 cents per ton. (As shown herein the average expense was close to 3 cents per ton.)
5. If we equate the institution of land reclamation provisions with effective enforcement of such requirements, the State of Kentucky commenced the former in 1964.
7. Revisions of the land reclamation requirements were made almost every two years after the enactment of the original 1954 statute. The more significant revisions were made by the Kentucky General Assembly in 1964 and 1966.

The other three steps, numbers 2, 4, and 6 concern the measurement and comparison of costs—specifically—the need to calculate internal expense increases and external cost decreases. These computations and their comparisons were not accomplished.

Requirements to reclaim the land after the surface mining of bituminous coal are applied to all surface mining operations. While the expenses to perform the reclamation are similar for all firms,<sup>17</sup> the reductions of external charges upon society vary from area to area.<sup>18</sup> For example, the external costs arising from any given min-

17. Differences exist, however, on a per-ton-mined basis due to varying coal seam thicknesses.

18. That is, from area to area in eastern Kentucky. Different reclamation provisions do exist for such mining operations in western Kentucky where the contour method of mining is not used.

ing operation are higher in the relatively more densely populated areas. Acid mine water and silt and sediment material, for example, cause higher external costs in areas containing roads, bridges and bodies of water than in relatively isolated localities. Thus, while the increase in internal expenses per acre disturbed are almost uniform, the reductions in external costs will vary according to the location of the surface mining operations. These results might have been different if another approach had been used by the State.

Deviations from the prescribed land reclamation provisions are allowed in some cases in eastern Kentucky, but only when such exceptions cause higher rather than lower external costs. For example, if the acidity of the removed overburden is so high that vegetation cannot survive, the mining operator may be allowed to revegetate equal acreage of other unreclaimed mining sites. Thus, for any site with this high acidity in a given population density, an area causing relatively lower external costs may be substituted for one causing comparatively higher costs.

A higher total reduction in external charges may be achieved if the reclamation provisions were viewed as minimum rather than maximum standards. Selective deviations in the extent of required reclamation would then be made toward more instead of less external cost reductions.

A government body administering a land reclamation law should include all seven of the aforementioned steps in its administrative procedures. This inclusion will insure that recommended or instituted changes in surface mined land reclamation provisions are first assessed and compared with estimated and actual external cost reductions.