THE ECONOMICS OF MINED-LAND RECLAMATION

by

David B. Brooks
Chief, Division of Mineral Economics
Bureau of Mines, U.S. Department of the Interior
Washington, D.C.

A demand for public action in the economic field is usually a reflection of the fact that, at least for some people, the private sector is yielding unsatisfactory results. This fairly describes the current situation as regards environmental protection. Many if not most people have concluded that private firms acting without public constraints will produce a higher than acceptable level of pollution. Unfortunately, whereas the demand for public action is quite general, the public response must be highly specific; the Government must decide when, where, and how to act.

The theme of this paper revolves around the need for Governments to formulate environmental protection plans for both abandoned mine sites and ongoing mining activity. Therefore, the first thing I will discuss is why environmental problems almost invariably become public policy issues. Second, I will discuss how we can make the needed economic evaluations of suggested policies or programs. Finally, I want to suggest some things that such evaluations can tell us about appropriate public actions.

WHY A PUBLIC POLICY PROBLEM ?

In some ways there is little that is new about the economics of mined-land reclamation. Every mine affects the land and the rest of the environment just by breaking the surface, and, conversely, the character of the land always affects the mining system in some way.

However, if the land problem is old, today's approach to it is new. Formerly land and the rest of the environment were viewed simply as obstacles that had tc be overcome on the way to getting minerals, and the engineer's objective was to minimize the costs of overcoming them. But today we have come to realize that value is placed on preserving the non-mineral benefits of the environment. In other words, the miner now deals with two productive resources--the minerals and the environment.

The origin of this shift in emphasis is perhaps obvious. On the one hand, the minerals industry is using increasing amounts of land. The most dramatic figures relate to surface mining: over the past

twenty years the proportion of coal recovered from surface mines has increased from 20 to 35%; the proportion of iron ore, from 75 to 90%; and the proportion of copper ore from 66 to 80%. 1/ Deep mining also makes demands on land use. According to Bureau of Mines estimates, some 2,000,000 acres (3,125 square miles) have been undermined to such a degree that they have subsided. Probably moreimportant, about 158,000 of those acres (250 square miles) are in urban areas. And there are solid wastes as well. Through 1966 around 19 billion tons of solid waste exclusive of strip mine spoil have been produced by mining and mineral processing, and this waste covers around 1.8 million acres.

But others also have a demand for this land. For convenience let outdoor recreation represent all non-mineral uses of the environment. Between 1965 and 1966--half the number of years noted above for the growth of surface mining--visits to National Parks doubled; visits to National Forests for recreation purposes doubled; and expenditures by the public for outdoor recreation more than doubled. 2/ If we mentally add other demands for land to this one, it becomes obvious why the minerals industry must now treat the environment as productive.

However, these trends do not get to the heart of the matter. All they show is that there is a conflict, a growing conflict, between those people who want to use land for mineral extraction and those who want to use it for another purpose. We must still answer the real question of why the conflict becomes a public policy issue. After all, we have hundreds of conflicts over resource use in our system, but ordinarily we let the private market decide who gets what, and also how much he must pay for it. In this sense, conflict is only another term for competition; we leave the decisions to private parties and assume that their actions, without public intervention, serve the public interest.

But there are instances where the public does intervene in the market, and let us examine the rationale behind a few such situations. In some cases the Government actually prohibits production, as with opium. In this case production is forbidden because it is believed that the social costs that attend use of this commodity are much greater than any private returns that might accrue to the producer. Another case is the public utility. Public utilities operate in sectors where it has been found technologically efficient to have a single producer--one telephone line, one gas pipeline--but having encouraged the formation of a monopoly, Government has to act as an overseer to prevent abuses in pricing and service.

What rationale might underlie Government involvement in pollution problems generally and mined-land reclamation specifically? The answer is that mining is one of a number of productive activities in which the very act of production does, or at least can, result in costs that do not appear in any market transaction or that do not appear in the correct one, which indicates that the market system is not operating

as it should.

This is a little abstract so let me approach it by contrasting two terms: internal cost and external cost. Internal costs are those that any mine operator must take into account because they appear on his account books: costs like explosives, fuel, and wages. These are the costs that the firm attempts to minimize. However, there may also be external costs, of which pollution is a prominent example. But consider first a simpler case, blasting. If a mining firm sets off a blast that breaks someone's window, this firm has imposed a cost, but one that does not necessarily appear on its account books and one that it therefore has no incentive to minimize. Fortunately, legal recourse has been adequate for most problems raised by blasting, but the court system is not well adapted to deal with pollution where the sources may be several and the damages diffuse.

A number of authors have documented the external environmental effects of mining. 3/ Consider a strip mine that dumps waste over the side of a hill into a stream. In effect, the mine is treating this water as a free good and therefore lowering its own costs. But this act may impose higher costs on a farmer downstream when the water table is raised or fields flooded as a result of sediment-clogged streams. The public may pay higher costs as culverts are clogged or road banks eroded. Cities may have to pay higher treatment costs for their water. All of these are measurable costs that are imposed by the mining operation.

The point is the following: from the perspective of the whole economy--not just the single firm--external costs are just as important as internal costs. Moreover, just as efficiency for the firm requires private cost minimization, so does efficiency for the economy require social cost minimization. This means that the economy must be one in which total costs of production--including direct production costs, waste disposal costs, and external environmental costs--are minimized. 4/ And here we have the essence of the problem: those with control over external costs have no incentive to minimize them; those with the incentive to minimize them have no control over them. 5/

This already suggests some conclusions. It would appear that efficiency in the economy could be improved by institutions that will force external costs to be considered by those who cause them. Also, the figures indicate that the problem of mined-land reclamation is much bigger than coal strip mining. It includes all of the effects that mining imposes on the land surface regardless of the commodity involved or the type of mining. 6/ And, further, statements to the effect that mining occupies only a very small part of the land surface are quite irrelevant when the effects that we are worried about occur downslope, downstream, or downwind of the mine site.

In short, all mining and mineral processing operations have effects on the land surface, and some of these effects impose damages. When

external costs are large and widespread, the free market may yield results that are far from ideal and this fact provides the rationale for public action.

THE BENEFIT-COST APPROACH TO PUBLIC DECISION MAKING

So much for generalities about why mined-land becomes a public policy problem. For our purposes, the important thing is that once we have recognized a policy issue, we also need a decision model, for by the very definition of the problem the market system on which we rely for most decisions is inadequate.

The economist's suggestion for such a model is, in one form or another, benefit-cost analysis. This approach was originally developed to decide whether government investment projects like dams were worthwhile, but it can be adapted to great advantage in proposals for pollution control and environmental protection.

Briefly, benefit-cost analysis is based on the assumption that there is always a variety of possible courses of public action and that these alternative courses will vary in effectiveness (i.e., benefits) and cost. Since selection must be made among the proposals, the goal of the framework is to rank alternatives by evaluating both the benefits to be gained and the cost entailed by each. (Or, what comes to the same thing, to compare what would happen with some new policy or program in effect and what would happen without it.) Furthermore, inasmuch as the alternatives will vary in their impact on various groups in society, it is also essential to identify who will receive the benefits and who will pay the costs.

In the case of mining and mineral processing, there are alternative ways to effect (1) elimination of adverse environmental effects at abandoned sites and (2) regulation of existing operations so as to reduce or eliminate adverse environmental effects. The difficult part is that all costs and all benefits should be included, and they must both be valued correctly. As you can well imagine, this is no easy task. Obviously, we can hardly hope to touch on even the high points of benefit-cost analysis here. But I can suggest something about the kinds of information needed to make it work.

Damage Functions and Benefits

The simple fact that wastes are present in the evnironment does not per se indicate pollution. Rather, as implied above, pollution occurs only when waste disposal practices--or the lack of them--have adverse effects on other parties. In order to determine the benefits that can be obtained from different practices, it is essential to have some idea of the nature and extent of the damages. As stated in a recent report:

> "The heart of the waste management problem involves (1) determining the impact of waste discharges on quality of the environment, with impact measured by the time pattern of concentrations of wastes; and (2) determining the effects of time patterns of waste concentrations on users of water, air and land." 7/

Potential benefits can be estimated from damage functions. A damage function relates the quantity and quality of wastes discharged to the resulting effects measured as economic costs. For example, in Figure 1 a given output yields a certain quantity of waste which in turn causes certain damages depending upon the level of treatment. Admittedly, this illustration is oversimplified, but it does show that damage reduction is the objective and that benefits can be obtained by shifting the damage function (as from the solid to the dashed line).

In addition, the shape of a damage function can tell us a great deal about the benefits to be derived from either regulations or reclamation. It could indicate that there is a threshold concentration of some effluent below which no damages are discernable for a given use (as with point A in Figure 1). For example, suspended sediment of colloidal size may present no adverse effects in water intended for agricultural use, though it would be most unpleasant for recreational use. On the other hand, the damage function could indicate that considerable reduction of an effluent is required before economic damages are appreciably reduced (as between points B and C). This is likely to be true for acid drainage within the pH range of 3 to 5.

Different population densities and different concentrations of economic activities are bound to influence the level of damages. For example, the economic damages resulting from an equal degree of subsidence may be negligible in a wooded area but high in an urban one. In other instances, the damages may be related to variations in stream hydrology, with greater damages occurring during times of low water flow.

Finally, an attempt must be made to identify, if not measure, intangible damages. The most important of these are primarily aesthetic, such as the difference between a clear mountain stream and a muddy or rubble-filled one. Fortunately, some procedures have been developed to deal with such cases that avoid the need for direct estimation of benefits. The differences among land values for locations with different levels of quality have been used for this purpose. Among other measures are the extra distance people will drive to find an unpolluted (or less polluted) recreation area, the added cost of sound insulation in the home, and the higher medical expenses from living in certain areas. 8/

One form of damage deserves special mention because it can be critical in certain regions, viz. the effect of mine effluents, sub-

sidence, or abandoned mines on economic development. The difficulty lies in the need, first, to project the course of development with and without alternative waste disposal policies or reclamation programs and, then, to translate any differences in the rate of economic growth into benefits attributable to improved management of mining wastes. Regional income may have to be an explicit goal before such benefits can be counted.

Cost Functions and Costs

The second half of a benefit-cost analysis involves estimation of the costs of accomplishing whatever treatment procedure or reclamation program is proposed. These are reflected in cost functions, which show the expense of alternative waste management schemes plotted against the rate of production.

In planning, cost functions should be evaluated for a wide variety of alternative techniques. At one extreme may be those that require only increasing the efficiency of existing processes; at the other may be possibilities for regional waste management or for relocating entire communities. Even within a mine or plant, there are alternatives that may have very different cost functions. For example, treatment of some effluent may be quite expensive per unit treated but overall control costs reduced by process changes that diminish the volume of waste generated. 9/ In any case, research can be expected to cut the costs of waste management as attention is directed to them.

The cost function for each waste management alternative will consist of both investment and operating costs computed in terms of the quantity or quality of waste treated and in terms of the results (that is, reduced subsidence, less discharge, or whatever). These cost measurements are likely to show two significant aspects. One is economies of scale. That is, the cost per unit of waste treatment or of land reclamation is likely to decrease significantly as the volume of waste treated or land reclaimed increases. It is this consideration that suggests the possibility for regional treatment of certain pollutants or for regional redevelopment schemes. The other aspect likely to be shown by the cost information is diminishing returns. In most cases, the cost of treatment rises very steeply as 100 percent removal of some particular pollutant is approached. The comparable difficulty with reclamation may lie with the increase in expenditure as the time allowed for reclamation diminishes, or as a greater degree of reclamation (to the limit of returning the land to its original state) is approached. This aspect suggests that except for the most virulent kinds of pollution (which are not likely to occur with mining) a balance should be struck between the costs of controlling adverse effects and the results (benefits), which is the subject of the next section.

Comparing Alternatives

The data collected on damage functions and cost functions provides the information needed to determine the most efficient policies and procedures for dealing with the adverse environmental effects of mining. Unfortunately, the procedures for comparing benefits and costs are not simple. A large literature has grown up around the subject, for many assumptions and qualifications are necessary. They cannot be dealt with here, but a simple case can be illustrated in Figure 2. The line sloping downward to the right indicates the marginal (additional) damages avoided throughout the economic system if wastes are held or treated to the indicated levels. The marginal costs of this procedure for all affected parties are represented by the other line. The optimum solution for this case is represented by treatment or withholding of waste to the level indicated by "X". Note that some damages continue (those represented by the area CXD) but that the costs to society of reducing those damages (the area CXDB) would exeed the damages. However, the optimum level of control procedure has reduced damages by an amount represented by the area YOXC at a cost of AOXC.

Actual cases are of course far more complex. There are likely to be a variety of sources and kinds of waste and many alternatives for waste management, subsidence control, and the like, each of which has a different impact on the environment. Further, since the optimum level of abatement permits some residual damages, it is important to determine who is suffering from them. The optimum solution on efficiency grounds might be politically unacceptable if most of the residual costs are imposed on an already disadvantaged group, or if it causes an increase in unemployment in a depressed area. 10/ Despite all of these complications there is every reason to think that optimum solutions can be developed for various waste management problems. Or, where non-economic issues are involved, the costs of suboptimum systems selected for social or political reasons can be measured. 11/

PUBLIC POLICY

We can bring these several threads together by suggesting some conclusions relevant to policy formulation for mined-land reclamation. The main point of the paper has been that benefit-cost methodology, while no panacea and despite numerous qualifications, offers the most useful approach to developing rational public methods for dealing with the several aspects of mined-land reclamation.

Consider first abandoned mining areas, which are somewhat easier to deal with than active mines because certain of the qualifications become irrelevant or even positive factors. For example, not only are aesthetic benefits obtained but employment opportunities are created. Nevertheless, given the large number of acres affected in many different states, one has to ask where money should be spent, and he must follow this up by asking how much money should be spent in any select-

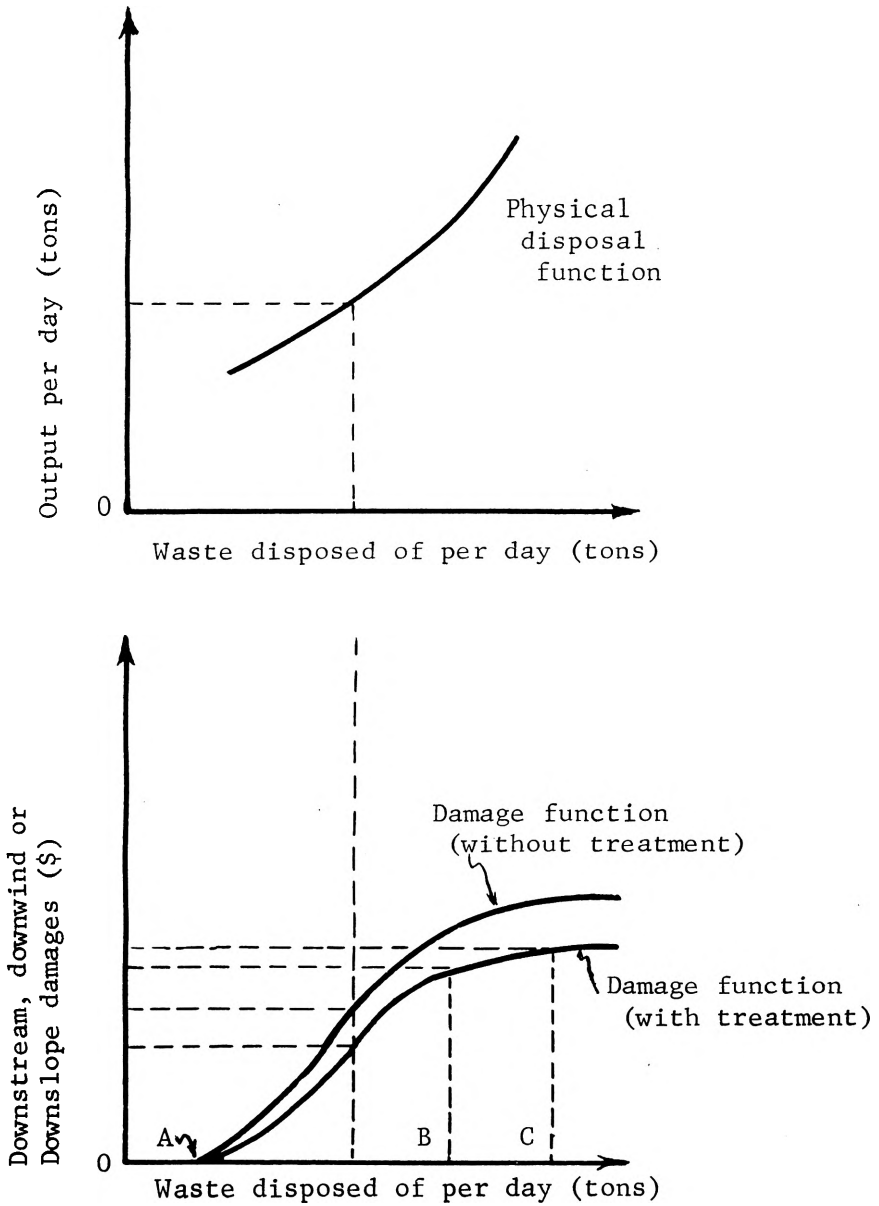

Figure 1.--Relationships between mine output and

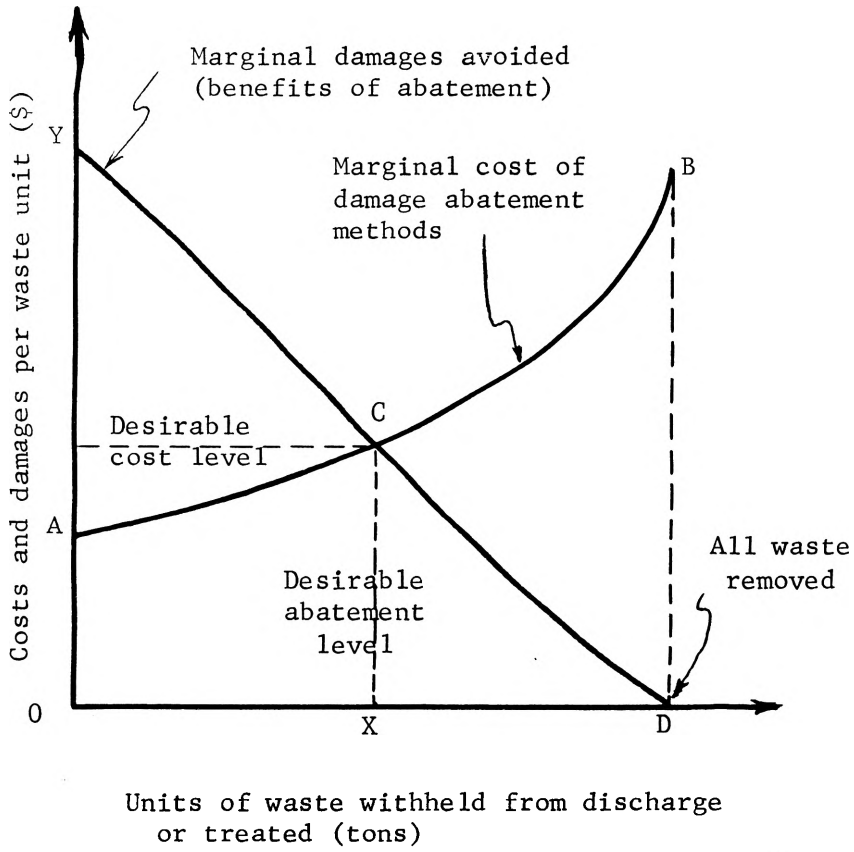

Figure 2.--An optimum level of waste management. (After Kneese and Bower, op. cit., p. 82.)

ed area. Even casual benefit-cost analysis can suggest answers. To me it appears that the damages from past mining are so much greater, and the alternative uses to which mined land could be put so much more important, that the bulk of any funds should be spent in the urban and near-urban areas of the East. Part of this reclamation will simply be designed to eliminate continuing external costs ("basic reclamation"), but much will require the additional analysis necessary to justify more expensive special-purpose rehabilitation.

Regulation poses even more difficult problems. Any regulatory system must be able to deal with three questions. The first is whether the reservation of some tract for mining, which is commonly a single-purpose use of land, is justified under the particular circumstances at hand. This requires a comparison of the net returns from various ways of using land, and consideration of such possibilities as sequential land use, hillside zoning, and scenic easements. Secondly, a regulatory law must consider what controls will be exercised during the mining process itself. The objective of the control scheme should be to force firms to take external effects into account. Ideally, the stringency of the control should depend upon expected external damages. (One possible technique involves "effluent charges" or taxes based on the quantity and quality of waste discharged. Their advantage lies in the fact that the charge can vary with, say, hydrology, so that it is more expensive to dispose of waste during low-water periods when pollution levels tend to rise. Effluent charges offer the additional advantage that they induce private research funds to be devoted to the more costly stages of the waste management program.) And, third, any regulatory scheme must consider the plans for closing of mines and quarries. This is a part of regulation because preplanning for the eventual use of the land is essential if total costs are to be minimized. There is no need to go back to the pre-mining conditions, but if the land is to be mined, it must be possible to return it to a condition that is both pleasing and productive.

Before closing I should admit that despite my emphasis up to now, we are not going to be able to wait for optimum solutions before acting. There is a clear public demand for both the reduction of pollution from today's mines and the reclamation of areas scarred from past mining. It is not so clear what levels of environmental change are tolerable, but present levels are no longer acceptable.

This suggests two final points. First, we should not be afraid of formulating approximate or temporary solutions. What we <u>should avoid are prescriptions that</u> lock the environmental protection plan into some inefficient institutional or technologic path. Since research almost invariably makes waste management less expensive than first estimated, public action should be flexible enough to permit private firms to adopt new solutions for environmental problems as these become available.

And, second, complete benefit-cost analysis is not likely to be

achieved--or even be necessary--in all circumstances. It has to be expected that some data will be missing and some functions only poorly known. But neither of these difficulties obviates the need for making decisions in the present. And, hopefully, the partial analyses we can make will indicate just those areas in the physical and social sciences where further research and data collection could do most to improve our capability for making subsequent decisions.

1/ Bureau of Mines, Minerals Yearbook (Washington, D.C.: annual issues).

2/ U.S. Bureau of the Census, Statistical Abstract of the Unites States (Washington, D.C.: annual issues).

3/ See for example, Surface Mining and Our Environment, A Special Report to the Nation by the U.S. Department of the Interior (Washington, D.C.: Government Printing Office, 1967); David B. Brooks, "Strip Mine Reclamation and Economic Analysis," Natural Resources J., vol. 6 (January 1966), pp. 13-44; Peter T. Flawn, Mineral Resources (New York: Rand McNally & Co., 1966), esp. pp. 251-63.

4/ This formulation of the problem is developed at length in the excellent book by Allen V. Kneese and Blair T. Bower, Managing Water Quality (Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1968), 328 pp. See also the statements by Jack W. Carlson and Donald F. Hornig in Joint House-Senate Colloquium to Discuss a National Policy for the Environment, Hearings before the Senate Interior and Insular Affairs Comm., 90th Cong., 2d Sess. (July 17, 1968), pp. 31, 46, and 164-72.

5/ Because I am trying to identify underlying forces, this statement deliberately neglects coluntary efforts for environmental protection undertaken by many firms.

6/ This concept is recognized by the Interstate Mining Compact: "'Mining' means the breaking of the surface soil in order to facilitate or accomplish the extraction or removal of minerals, ores, or other solid matter; any activity or process constituting all or part of a process for the extraction or removal of minerals, ores, and other solid matter from its original location; and the preparation, washing, cleaning, or other treatment of minerals, ores, or other solid matter so as to make them suitable for commercial, industrial, or construction use; but shall not include those aspects of deep mining not having significnat effect on the surface, and shall not include excavation or grading when conducted solely in aid of on-site farming or construction."

7/ Blair T. Bower and others, Waste Management, A Report of the Second Regional Plan (New York: Regional Plan Assn., 1968), p. 30.

8/ Allen V. Kneese, "Economics and the Quality of the Environment--Some Empirical Experiences," in Social Sciences and the Environment, Morris E. Garnsey and James R. Hibbs, eds. (Boulder, Colo.: Univ. of Colo. Press, 1967), pp. 168-74. H. O. Nourse, "The Effect of Air Pollution on House Values," Land Economics (May 1967), pp. 181-89.

9/ This effect is well documented by G. O. G. Lof and A. V. Kneese, The Economics of Water Utilization in the Beet Sugar Industry (Washington, D. C.: Resources for the Future, Inc., 1968). In surface mining, Ohio Power Co. found that minor shifts in shovel oper-

ation had a significant impact on reclamation costs. See Rodney R. Krause "Equipment and Extractive Advances," Proceedings: Coal Mine Spoil Reclamation Symposium (University Park: Pennsylvania State Univ., 1965), pp. 77-81.

10/ This effect can be significant. See David B. Brooks, "The Impact of Surface Mine Regulation on the Coal Industry: The Case of Kentucky," Proceedings of the Council of Economics of AIME, 1969 (in press).

11/ See Kneese and Bower, op. cit., and the works cited therein. See also Samuel H. Brock and David B. Brooks, The Myles Job Mine: A Study of the Benefits and Costs of Surface Mining for Coal in Northern West Virginia (Morgantown, W. Va.: Appalachian Center, WVU, 1968), 61 pp.; Richard A. Tybout, "A Cost-Benefit Analysis of Acid Mine Control," Second Annual Symposium of Acid Mine Drainage (1968), pp. 334-71; William A. Wallace et al, "Planning for Common Mineral Resources; A Computer Simulation Approach," Paper delivered to Soc. of Mining Engineers (October 1968), AIME preprint.

COMMENTS

QUESTION: Dr. Brooks, a lot of your discussion tended to be without specifics. This morning Mr. Cook mentioned figures something like $17.00 an acre spent on reclamtion in one place and I have seen figures, from Pennsylvania where over $2000 an acre was spent on reclamation. In some places $50 an acre is a high price for the original land. Would you address yourself to this problem relative to your cost benefit analysis.

REPLY: In the first place I don't think that basic reclamation to eliminate many damages is going to cost $1500 to $2000 per acre. In the mountains where you are trying to restore the surface or where you are trying to create some special feature I don't know what the figures would be. In the analysis I am going through which is for a general condition you shouldn't be spending that much if you can show that what you are getting out of it is simply not worth $2000 per acre. There will always be things that may not make sense because we say there are damages we can not measure. Asthetic effects are hard to determine and the people who are receiving these damages are either particularly deserving or have a particular problem. I think very largely this is going to be the rational in Appalachia. In Appalachia I have great difficulty finding tangible economical damages that I could point to as streams that are damaged that are very unproductive and fields that have been destroyed that are very unproductive. The people are not producing very much in the area and yet I feel a little uncomfortable going that way with their fear of strange ways. You can buy quite regularly Appalachian land for $50 an acre and the man you purchase from ends up with $3000 for his land, probably a very fair price. He may end up on the public welfare rolls some place elsewhere before he was a subsisting farmer in Appalachia. Perhaps you are transporting the basic problem from one place to another. Specifically it is that you shouldn't be spending $2000 if you can't show $2000 dollars worth of value. Also this $2000 may be spent by the company and the return of this money show up somewhere else in the economy. That is perfectly legitimate from my point of view.

COMMENT FROM THE FLOOR: I'd like to comment on that figure of $2000 per acre that was mentioned in Pennsylvania. This is an area of a State Park and which the park people wanted the reclamation done in a particular manner for park purposes. This is not the cost of the reclamation of the strip-mined land in Pennsylvania's reclamation work. We require the operator's to put up a bond of $500 per acre. There have been some areas where the strip mine operators have had to put up a larger bond than that in order to guarantee the restoration of the land to approximate original contour or terrace type contour, but I don't want to mislead anyone and have people think that it costs $2000 per acre to reclaim strip-mine land.

COMMENT FROM THE FLOOR: It seems to me that there is one thing that should be considered with regard to the cost to the industry of modifying mining methods. To prevent the creation of pollution disorders, which will last for some time, there is a lesser cost to the industry at the time that the work is done as opposed to the cost to the public of having to do it at some later time.

And a second thing I'd like to say with regard to that is that I think the value of the resource that's being extracted should be considered in terms of the cost that may be required to correct the problem that relates to it. In other words you may expect the total value of the coal that's extracted to maybe be $1000. This is just an arbitrary number, but it may cost the public $2000 if they have to reclaim the land from which the mineral was extracted. And I'd like to ask a question of Dr. Brooks. If it is decided to go into projects relating to the reclamation of abandoned mine areas, do you have any comments on the most desirable way of financing this sort of thing, especially when it may be largely a regional problem?

Dr. Brooks: I agree with essentially everything you said. My own opinion is that we ought to divide this pretty clearly into two separate programs in terms of finances: reclamation of past areas and mining into, whenever you decide that point, the future. I think reclamation in the past areas should be a public financing responsibility for the practical reason that you can't find out who did the mining in a community. Also for the principle that it was the public that got the benefit of the cheap resources and now the public ought to pay the cost to get it back. It is a public decision now to go back and fix these areas up. For the future however what we're really saying is that we want the full cost of production - the full cost of production meaning both the production costs as they looked in the past and the environmental impact to be treated as normal cost of production - so that as we go into the future these costs will be imposed upon the mining firm as part of the price of extracting the material. As a matter of fact, I think the public would favor legislation to do this. I'd rather see environmental costs taken out of competition in the same way minimum wage laws took cutting wages out of the realm of competition back in the 1930's. I think we ought to say that environmental work should be out of the realm of competition. No one should be able to undercut the price of coal or gravel or whatever you are producing because they're not observing their responsibilities for reclamation.

COMMENT FROM THE FLOOR: I would like to make a comment. When you say that this takes reclamation out of the competition area, I think we can get back to the price of the product. If there's one place where we know that the mineral industry is weak, it's in what they get for the end product. Perhaps work in this area to adjust costs more realistically in the sale of this end product to the consumer is an area that needs some work done on it. We have to look at reclamation costs as a new dimension in mining and adjust the sale price of the product accordingly.