BRIEF ON THE ENVIRONMENTAL IMPACT AND REGULATION OF SURFACE COAL MINING IN ALBERTA

A submission by

Canada Department of the Environment

for

Public Hearings held by the
Alberta Environment Conservation Authority
Dec. 21, 1971, Calgary, Alberta

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A. BASIC ECONOMIC ANALYSIS OF THE COAL MINING INDUSTRY IN ALBERTA

1. Resources and Markets

The Province of Alberta is richly endowed with coal resources. Most recent estimates[1] indicate that the province contains 47.2 billion short tons in place. Of this total, 5 percent or 2.2 billion tons are "measured" 68 percent or 32.1 billion tons "indicated" and 27 percent or 12.9 billion tons are "inferred" resources. Of total Western Canadian reserves Alberta alone accounts for 40 percent. Most of Alberta's coal resources are of bituminous and sub-bituminous rank. Resources of bituminous coal, much of which is of good coking quality, are located in the mountain and foothills region, whereas sub-bituminous coal deposits occur in the plains. Estimates indicate total bituminous and sub-bituminous reserves at 37.3 billion and 9.9 billion short tons, respectively.

The revival of the Alberta coal industry in recent years is directly attributable to the demand from two main markets: the Japanese steel industry and the thermal-electric industry. Four Alberta companies presently have contracts to export 4.3 million short tons of bituminous coal to Japan in 1971, and 5.4 million annually to 1975[2]. It can be expected, also, that some major industrialized countries presently faced with

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[1] Latour, B.A. and Christmas, L.P. 1970. Preliminary estimate of measured coal resources in Western Canada. Paper #70-58, Dept. Energy, Mines and Resources, Ottawa.

[2] Christmas, L.P. 1970. Coal and Coke. Paper #14, Mineral Resources Branch, Dept. Energy, Mines and Resources, Ottawa.

shortages of high quality coking coal will be looking for new sources of supply. Among these new sources will be Canada - and in particular Alberta. The National Energy Board of Canada has forecast coal production in Alberta to increase to 11.6 million short tons by 1975, and to 32.4 million short tons by 1990. This projected production for 1990 represents a five-fold increase over 1970 production. However, these figures predict that by 1990 less than 5 percent of Alberta's total coal reserves will have been tapped. Both resources and markets indicate therefore that the coal industry in Alberta will expand and remain viable for many years.

2. Firms and Employment

Since the mid-60's the trend has been to larger but fewer mines. Only by shifting in this direction can the industry benefit from the economics of scale. In 1965, 44 mining companies were in operation; only 28 were in operation in 1970 (Table 1). Of those mines operating in 1970, six produced over 90 percent of total production. The large capital investments required to expand existing operations presents a formidable barrier to most smaller companies and, therefore, further decreases in the number of operating mines is likely. Although the coal mining industry, like the petroleum industry, is not labour intensive, it is anticipated that there will be a significant increase in primary employment as a result of production increases to meet future market demands. In the period 1965-70, for example, coal production increased by 97 percent while primary employment rose by roughly 50 percent. By 1975, primary employment in the industry could reach 4000 people[1].

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[1] Western Coal Operators Association.

3. Surface Mining Projections

Since 1965, approximately 70 percent of Alberta's coal production has been surface mined by open pit and strip mining methods. It can be expected that this method of recovery will continue. From the viewpoint of the mining industry, surface techniques offer real advantages:

a) they make possible the recovery of deposits which, for physical reasons cannot be mined by underground methods;

b) they provide safer working conditions;

c) they usually result in more complete recovery of the deposits; and

d) most significantly, they are cheaper in terms of unit costs.

Additionally, productivity per man-day is much greater than in underground mining (Table 1).

It has been estimated that approximately 7 square miles of land area have been disturbed by surface mining activities in Alberta to 1970. Surface mining in the mountain and foothill regions of Alberta had until recently disturbed less than 800 acres. Rough estimates of acreages to be surface mined over the next two decades, deduced from the National Energy Board forecasts, predict that by 1990, Alberta strip mining will occur at a rate of 2,200 acres annually. At least 32,000 acres could be strip mined for coal over the next 20 years in the foothills belt between the Crowsnest Pass and the Smoky River.

Table 1. RELATED SURFACE AND UNDERGROUND MINED COAL PRODUCTION STATISTICS FOR ALBERTA

YEAR	PRODUCTION			VALUATION AT THE MINE				AVERAGE OUTPUT PER MAN-DAY	
	SURFACE MINED	TOTAL COAL MINING	AMOUNT SURFACE MINED	TOTAL VALUATION	VALUE PER TON	NO. MINES IN OPERATION	AVERAGE NO. MEN EMPLOYED	SURFACE MINING	UNDERGROUND MINING
	000's tons		percent	dollars				tons	
1965	2,437	3,414	71	12,172,000	3.57	44	1,180	27.5	4.9
1966	2,426	3,467	70	12,067,000	3.48	37	1,150	31.9	5.2
1967	2,601	3,601	72	12,506,500	3.47	35	1,160	37.7	5.1
1968	2,988	3,925	76	12,597,200	3.20	30	1,100	47.8	5.0
1969	3,334	4,426	75	13,483,000	3.04	29	1,210	49.7	5.3
1970	4,735	6.783	69	26,710,500	3.93	28	1,760	46.4	7.9

Source: Alberta Department of Mines and Minerals

Canadian Minerals Yearbook
Mineral Resources Branch
Department of Energy, Mines and Resources
OTTAWA

4. Social Benefits

Albertan benefits are for the most part measured by direct and indirect employment opportunities, revenues generated for provincial and local governments, and the kilowatts of low cost electricity which provide a source of energy for homes and businesses. Table 2 denotes some of the values of these benefits.

Table 2.

SOME BENEFITS DERIVED FROM ALBERTA'S COAL MINING INDUSTRY

Year	No. Employed[1]	Salaries & Wages[1]	Provincial Income from Royalties and Leases[2]	Thermal-Electric Energy Generated
		dollars	dollars	million KWH
1965	1,181	5,732,620.	236,605.	1,800
1966	1,146	5,867,748.	258,420.	2,150
1967	1,162	6,101,263.	299,479.	2,200
1968	1,103	6,268,632.	421,730.	3,300
1969	1,209	8,308,628.	642,640.	3,800
1970	1,757	n.a.	652,188.	5,000
1971	-	-	1,640,885.	-

[1] in direct employment only

[2] ending March 31st of year indicated

Sources: Alberta Department of Mines and Minerals
Statistics Canada: Coal Mining Industry Cat. No. 26-206
Alberta Power Commission

Although employment opportunities are created by the presence of the coal mining industry and its related activities, it is not a labour intensive industry. In 1970, for example, direct employment in the industry constituted less than 1 percent of the total Alberta labour force. Introduction of an employment multiplier to determine the expansion effect does not increase the total numbers employed in other sectors of Alberta's economy significantly[1].

On the other hand, wages and salaries paid by operating companies, income accruing from royalties and leases, and tax payments have a direct impact on the province's economy. A portion of this money will be spent and respent within the Alberta economy, generating further income and labour demand.

The mining industry as a whole is capital intensive. It is recognized that a percentage of initial development outlays and annual operating expenditures are, and will continue to be, spent outside the province. These expenditures are primarily for large mobile equipment and their replacement parts which are not normally available from Albertan manufacturers. In this respect, Albertans will not receive the total benefits that would accrue if all capital outlays were spent within the province, they will be shared with other Canadians and North Americans.

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[1] A conservative estimate from several sources suggests a 1:1 ratio of direct to indirect employment within a mining community. The ratio would be slightly greater for the province as a whole.

Reclamation of areas disturbed by surface mining is itself an employment opportunity. Employment of students and contractors by mining companies to reclaim spoiled areas would help, to a certain degree, to reduce the employment problems of the summer months.

5. Social Costs

In transforming coal resources and other resources into economic wealth, Albertans have paid little attention to long-term environmental consequences. The very act of production associated with surface mining of coal generates a number of side effects or spillovers from the activity. It is these spillovers and their associated costs that are commanding immediate attention by the people of Alberta who should not be required to absorb these costs. Unlike benefits which can be described quantitatively, the external effects of surface mining are either intangible in value or not subject to direct measurement at present. In short, the resource user, not the public, should pay for damages occurring external to his basic activity. Like clean water or clean air, environmental goods such as scenery, undisturbed open space and the presence of wildlife are public goods and should be jealously guarded and protected by Albertans, and open to the enjoyment of everyone. Albertans must be careful which resources they give up or "trade-off" to industry in return for the benefits provided. Allocation of areas for industrial activity in combination with other land uses can be effectively determined by sound and unbiased planning which considers equally all resources, whether quantifiable in economic terms or not.

For the 12,235 square mile "Edson" region west of the Pembina River to Jasper National Park and north from the Brazeau River to the Smoky River, hunters spent 1.75 million dollars ($131.00 per square mile of Crown land) annually in the early 1960's[1]. The potential annual expenditure was slightly more than 4.0 million dollars ($333.00 per square mile). On the most productive "game" lands i.e. grassland and aspen, these values would be considerably greater per acre. The present and potential value of the fishing and trapping industries in the foothills may exceed the value of the above hunting industry.

External costs, whether social or economic, now face Albertans; these are, in part, the rationale for public regulations. Regulations for reclamation should therefore consider both the operating site and the disturbances that are created in the exploratory and development phases. Only by such regulations can industrial activity be made to serve and maximize the public interest.

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[1]Stelfox, J.G. 1965. The wildlife resource in C.D. 14 (Edson Region). Typescript report prepared for Resources for Rural Development in Census Division No. 14. Resource Study 800-884. 1, Farm Economics Branch, Alberta Dept. of Agriculture, Edmonton. 18 pp.

B. CO-ORDINATION OF SURFACE COAL MINING, ENVIRONMENTAL PROTECTION AND RECLAMATION.

1. Planning and Land-use Objectives

The key to successful reclamation is planning. Because it is not possible to conduct mining without some disturbance to the natural landscape, important questions in the planning are how much disturbance is to be tolerated and to whom is it important. The question of eliminating man-made environmental abnormalities is largely an economic one which can be answered by proper land-use planning.

One of the first questions to be asked in planning is what should be the reclamation goal. An undisturbed landscape? An aesthetic wasteland? A golf course? A park? Each alternative would find proponents and there is no goal that would satisfy everyone. To the purist there is no way to recreate an undisturbed landscape because the one that existed prior to mining evolved over thousands of years. The best that man could do would be to create an artificial imitation that superficially resembles the former landscape. On the other hand, it may be possible to create a more useful landscape. Reasonably flat or rolling terrain could be turned into a park, golf course or hiking-fishing area. Whatever the goal, it should be agreed upon and planned for prior to mining. The cost of achieving that goal must be anticipated and the responsibility for meeting it assigned on a rational basis.

Before there is any development for coal or other minerals in a particular region it should be determined whether there is some other over-riding land-use for which the area is better suited, and whether that use would preclude or limit surface disturbances. An obvious example of a land-use that would preclude surface disturbance would be land already reserved for parks because of its unique qualities. Land that has high recreational and watershed values because of its nearness to cities should likewise be reserved. Specific cases in Alberta would be the Pincher Creek-Waterton-Cardston triangle, the Elbow and Sheep drainages south-west of Calgary, and the Banff-Calgary, Jasper-Edson, and David Thompson transportation corridors to the national parks. In 1959 it would also have been possible to argue for a similar reservation in some portion of the Swan Hills of Alberta. These are examples of areas that should be considered for designation as a "Restricted Development Area" under the terms of the Department of the Environment Act.

All land is watershed and to some degree aesthetic and most lands support wildlife. Some land contains fish habitat and some has commercial value for timber or agricultural crops. In the development of the land-use plan and in the designation of "land management zones" it is necessary to ask what land resources are used now. Are they likely to be used in the future? Will the improved access that accompanies development result in new uses that are not present now? Will the disturbed area be visible from roads and other developments not directly connected with the mining

activity? Is the area surrounding the land to be disturbed, already developing according to an existing plan? All of these considerations must influence planning for reclamation. The need for planning, land-use zoning, and pre-determination of environmental policies and goals form the central rationale for the legislative recommendations in this brief.

2. Water and Aesthetic Management

Ground water flow patterns can be disrupted by strip mining. This disruption is particularly important in the mountainous source areas of the Saskatchewan, Smoky and Athabasca rivers of Alberta because very little overland flow occurs in these vegetated land areas. Most flow into these rivers originates as local or regional groundwater. Local groundwater systems recharge and discharge within the same catchment. Removal of the overburden from either the recharge or intervening transmission zone may alter the pre-existing streamflow regime.

Regional groundwater flow occurs across catchment topographic boundaries. Often the same recharge zones feed both local and regional groundwater systems, although the valley bottoms may also act as recharge zones for regional groundwater. Deep cuts made during surface mining generally encountered one or more groundwater flow systems and disrupt their normal flow patterns. It is not likely that reclamation measures can restore these disruptions. Seemingly minor land areas may have importance to the groundwater flow system far out of proportion to their size. Groundwater flow patterns are in general perpendicular to the foothills; coal seams

are parallel. Removing the overburden along the contour, therefore interrupts groundwater flow along a line that generally separates aquifers from their recharge areas. If extensive and contiguous areas of coal in the foothills are mined, serious shortages of groundwater in the adjacent plains could occur. Because pre-mining groundwater flow patterns can not be expected to reoccur after reclamation, these alterations should be considered as irreversible in the foothills and mountain areas.

Interrupted groundwater flow systems result in surface impoundment and flow. This impounded water must be removed during mining operations, and can cause erosion problems in small streams draining the area, if the water is added to them at a rate that increases their instantaneous peak discharge by more than 5 to 10 percent. Impoundment may also provide either a flood control or a flooding problem for downstream users. Impoundment of normal flow in small streams behind road crossings or other damming structures, whether permanent or temporary, alters the aquatic environment of the stream below the point of interruption. This has serious consequences for fish that may migrate up the stream or utilize it as a spawning and feeding ground. Once normal stream regimes are altered, each further release or impoundment must be governed by its effect on this newly established regime. Over a long period of time, downstream development may occur that precludes the desirability of re-establishing the pre-mining water regime. Reclamation plans must consider alternative regimes in this case.

The magnitudes and therefore the impact of the effects of surface mining on groundwater patterns, stream flow volumes, or stream flow regimes can not be generally predicted. Each situation must be evaluated individually. For example, the infiltration capacity of spoil material is often greater than that of the undisturbed land. High infiltration and storage reduces the instantaneous peak magnitude and flow volumes in streams during rain storms. However, rapid transit through porous overburden coupled with low storage retention can produce the opposite effect. Therefore, any alteration to the normal surface or subsurface drainage patterns should be considered as detrimental until the details of such disturbances have been evaluated on site, for each affected aquifer, and for channelized flow downstream. This evaluation should take place before mining starts within the concepts of overall water use.

Both physical and chemical water quality will be affected by strip mining. Groundwater flow forced to the surface can carry solid particulate matter overland into a stream. Local deposition of the sediment will affect fish spawning and feeding beds and aesthetics. Further downstream, suspended material entering reservoirs designed for flood control or power generation will accumulate and reduce their storage capacity. Sedimentation can be minimized by planning for siltation ponds prior to stream entry.

Chemical water quality will be changed because of new flow pathways. The effect and magnitude of change is impossible to predict without a thorough

knowledge of the surface and groundwater hydrology of the disturbed area. Changes may be beneficial, harmful or neutral. A program of overburden and drill core analysis to determine if substances which would adversely affect water quality will be released upon weathering could prevent problems. Any regulation of flow reduces the aesthetic quality of mountain streams, and increases of sediment and hardening chemicals, increase the water treatment costs of municipal water supplies.

3. Wildlife Management

Coal-bearing areas include lands that support aspen and/or grassland vegetation. In western Alberta these are productive and critical ranges for numerous big game and upland game bird species as well as many equally important non-game species. Notable of the "game" species are mule deer, elk, bighorn sheep, ruffed and sharp-tailed grouse and to a lesser extent mountain goats, caribou, moose, white-tailed deer, Franklins and blue grouse, and white-tailed ptarmigan. The streams and lakes of western Alberta abound in a rich and varied aquatic fauna including a diverse and abundant fish population. Numerous fur-bearing species are located within the coal-belt as well as several rare and endangered wildlife species such as the mountain caribou, mountain goat, bighorn sheep, wolf, grizzly and cougar[1] [2]. A 3,000 square mile area between

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[1] Boag, D.A. and W.G. Evans. 1967. Mountain habitats--in Alberta a Natural History, edited by W.G. Hardy. M.G. Hurtig Booksellers Ltd., Edmonton, Alberta.

[2] Stelfox, J.G. and R.D. Taber. 1969. Big game in the Northern Rocky Mountains coniferous forest--IN 1968 Symposium of Coniferous Forests of the Northern Rocky Mountains, edited by R.D. Taber. Center for Natural Resources, Univ. of Montana Foundation, Missoula, Montana.

the Brazeau and Smoky rivers supports some 2,900 moose, 2,600 deer, 2,500 elk, 2,200 bighorn sheep, 550 mountain goats, 600 caribou, 180 grizzly, 500 black bear and numerous other valuable non-game wildlife species. The critical nature of the grassland and aspen communities for survival of wildlife in the mountains can be appreciated when we realize that during the seven-month winter period in the mountains (mid-Oct. to mid-May) the wild ungulates are forced to winter on 10 percent or less of the total mountainous area, with many winter ranges supporting wild ungulate densities of 25 to 100 animals per square mile of range. Open grasslands and aspen pastures comprise over 75 percent of this confined winter range[1,2]. In total, the foothills and mountain region provide the diversity of habitats resulting from variations in altitude, exposure, soil and plant cover, that is required to support an abundant and diverse animal population.

Recent studies[3] of coal mining operations in the foothills and mountains of Alberta and B.C. have shown several cases where operations were deleterious to both wildlife populations and their habitats. One report documents four areas in western Alberta where serious damage has occurred. New developments in the Racehorse Creek, Coal Branch, Red Deer Valley

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[1] Stelfox, J.G. and R.D. Taber. 1969. Big game in the Northern Rocky Mountain coniferous forest-- IN 1968 Symposium of Coniferous Forests of the Northern Rocky Mountains, edited by R.D. Taber. Center for Natural Resources, Univ. of Montana Foundation, Missoula, Montana.

[2] Cowan, I. McT. 1950. Some vital statistics of big game on overstocked mountain range. 15th N.A. Wildlife Conference (1950), pp. 581-588.

[3] Kerr, J.W., L. Hamill, A.L. Harris and N.W. Rutter. 1969. Coal Mining Damage in Alberta.

and Smoky River areas are expected to pose serious problems to the wildlife resource. Mining sites in the Smoky River and Coal Branch areas lie in the heart of critical wild ungulate winter ranges. Mountainous ranges adjacent to Jasper, Banff and Waterton Lakes National Parks play a major role in providing the necessary winter range for wild ungulates which migrate each fall from the Parks to winter on the productive provincial winter ranges.

Wildlife and mining are not necessarily incompatible. The limestone quarry operation at Cadomin is an example of mining activities being reasonably compatible with the presence of bighorn sheep. Mining can be programmed to minimize the destruction of critical, wildlife habitat components, and to minimize harassment of wildlife populations. There is a dearth of knowledge on the extent and seriousness of the impact of surface mining upon wildlife populations and habitats. Research is required to document this impact and devise means of reducing it.

4. Environmental Impact Appraisal and Operational Research

Prior to mining in a given area an environmental impact statement should be supplied to the Government by the company stating the anticipated permanent or temporary damage to natural resources due to the operation, the time over which reduced environmental quality will exist in given areas and plans for environmental protection.

The environmental impact appraisal could be formulated as follows[1]:

(a) a statement of major objectives desired in the resource development project;

(b) an analysis of technological methods of achieving these project objectives;

(c) characteristics and conditions of the environment prior to the proposed development;

(d) possible deleterious changes in various characteristics of the ecosystem;

(e) an estimation of the magnitude and significance of these changes to the ecosystem;

(f) an assessment of the total impact, by analysis of separate impact events and ecological parameters; and

(g) a summation and recommendation.

The application of this concept to a typical mining operation would require an estimation of ecological changes due to the following project activities:

(a) construction of buildings and ancilliary facilities;

(b) construction of highways, railways, bridges and access roads;

(c) construction of transmission lines;

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[1]S.K. Krishnaswami, Environmental Protection Service, Department of the Environment; personal communication.

(d) blasting, drilling and related work;

(e) surface excavation and dumping;

(f) mineral processing and handling;

(g) slurry and other waste disposals; and

(h) spills and leaks.

Biological indicators of environmental quality are of considerable importance in determining the impact of a development. Changes in the density and productivity of aquatic and terrestrial plants, and changes in the health and distribution of fish and wildlife are early warning signs of environmental impact. The interpretation of physical and chemical measurements of environmental quality should be made in terms of these biological measurements and observations.

Operational research should obtain information on specific biological, chemical or physical techniques to prevent environmental damage and re-establish a suitable topography, stability and vegetation. In British Columbia, as a result of 1969 amendments to the Coal Mines Regulation Act and the Mines Regulation Act, all companies that are operating under the new legislation are engaged in reclamation studies of some kind[1]. Requirements for industrial participation in impact studies and operational research in Alberta would hasten the development of environmental protection methods and reclamation.

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[1] J.V. Thirgood and J.R. Matthews, "Progress in reclamation research in British Columbia during 1970", Mines paper presented at 15th I.U.F.R.O. Congress, Gainsville, Florida, 1971.

Operational research would also tabulate the costs of reclamation as it evolves to meet future land-use objectives and allow the company to weigh these costs against the benefits from the extracted mineral.

5. Land Capability Analysis

Land capability analysis can be used as an aid to obtaining coordination of surface coal mining with environmental protection and reclamation. Such an analysis may have valuable application to the development of coal in western Canada, particularly in the Rocky Mountains and foothills areas.

Exploration for coal can be expensive. It would be most desirable if those exploring for coal knew in which areas"

(a) coal mining would be prohibited entirely because of other over-riding land uses that would preclude the surface disturbances necessary for open-pit operations;

(b) coal mining would require extremely high standards of care to protect adequately the environment in all phases of the mining activity and reclamation such that the cost would make operations either uneconomical or borderline;

(c) coal mining would not require great expenditures to protect the environment because it can be protected by a good standard of care in mining practice and reclamation; and

(d) coal mining would be the most valuable resource and the land is of relatively little value for purposes other than mining.

It is equally important, although not necessarily only in economic terms, for the government and the people of Alberta to know the value of the land upon which they may permit coal mining.

It would be unwise to prohibit outright surface coal mining in large blocks of land without just and substantial reasons. However, there could be particular sections of land that have intrinsic values based on a combination of land uses such that to permit coal mining would be an unwise allocation of resources. Surrounding such sections may be land where very careful mining practices and expensive reclamation work would be necessary to protect the land.

In the past the cost of protecting the environment was not considered as one of the operating costs. Today, our laws require that the environment be taken into account. For example, the decision to allow tip dumping or not (as opposed to benching dumping) may determine whether or not an operation is economical. Unless guidelines as to what forms of dumping are permitted under certain conditions are made clear, a mining company cannot adequately evaluate the cost of environmental protection. A company should be able to include reasonably accurate figures for the cost of environmental protection in its feasibility studies at the same time other cost data are developed.

C. ENVIRONMENTAL PROTECTION DURING SURFACE EXPLORATION AND MINING FOR COAL

1. Water Quality Control

Since coal washeries and coal burning power plants require a supply of water, the larger coal mines are located on streams, rivers or lakes. A water quality monitoring and control program is therefore and integral part of environmental protection during these operations. All water courses that flow out of or through a mine site should be routinely monitored to determine downstream effects of the mining upon water and bottom quality. This becomes of increasing importance if changes in quality can effect the downstream or local use of the water for recreation, fish and wildlife, agriculture or human consumption. The water quality parameters most commonly altered by coal mining are suspended solids, turbidity, color, iron, manganese, organic carbon, nitrates, phosphates and alkalinity. The mass effect upon water quality of the weathering and leaching of minerals in large acerages of disturbed sandstone and shale has not been studied.

Because of the high pH's (7.5-8.5) and bicarbonate contents of most of the surface water in Alberta, the solubilities of inorganic ions such as iron and manganese are low, and if released, are soon oxidized and precipitated. A large part of the iron that enters streams appears to be derived from minerals contained in the overburden rather than the coal. Some elements such as iron and manganese appear to move in water

largely in the particulate fraction rather than in true solution. Proper sediment and erosion control will therefore reduce the possibility of these elements being carried downstream. Other elements such as nitrogen and phosphorus move in solution for great distances. Since the control levels in Alberta[1] are much lower for manganese (0.05 ppm) and phosphate (0.15 ppm) than for iron (0.3 ppm) and nitrogen (1.0 ppm), these elements require more careful monitoring. Each water quality parameter therefore requires a monitoring and control program that takes into account its unique biological, chemical and physical nature.

To prevent pollution, coal wash water must be discharged to large clarification ponds to remove coal fines and other refuse material. These ponds should be designed to accommodate many years' accumulation. Preferably the clarified water from the slurry pond is reused for washing coal.

Algal blooms in streams and lakes can be used as water quality indicators since these normally occur in response to added nutrients (nitrates and phosphates) which are released from the soil and vegetation when it is disturbed. Such blooms have been observed in late summer in portions of foothills streams affected by sediment and drainage from surface coal mining operations. Small lakes are quite

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[1]Alberta Surface Water Quality Criteria

vulnerable to accelerated eutrophication and need protection from sediment and inorganic chemicals that can leach from the surrounding land when it is disturbed, become concentrated in the lake, and cause algal and aquatic plant blooms.

2. Sedimentation and Erosion Control

Sedimentation and erosion controls during surface mining operations have not been given serious enough consideration in Alberta. Surface water entering streams and lakes from mining areas should not increase the suspended solids concentration by more than 10 ppm above the background level[1]. Since most sediment transport occurs during rainstorms, physical water quality must be monitored at these times to determine if this criterion is met.

The control of mine drainage should begin prior to the overburden removal. When a new pit or field is opened, care must be taken to divert all surface streams around the "action centre of mining". Diversion ditches should be constructed above the highwall to prevent surface waters from entering the coal recovery excavation. Pumps should be installed to convey precipitation and infiltration from the excavation as rapidly as possible. Diversion ditches may also be used to remove water from the excavation. These drainage control measures are usually necessary for mine operation and thereby serve a dual purpose.

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[1]Alberta Surface Water Quality Criteria

The prime way of combatting soil erosion is by keeping the area of disturbed, unvegetated land to a minimum. This objective is accomplished both by planned mining and by rapid reclamation. Drainage control and sediment catch basins must be used until revegetation is completed. Physical and chemical treatments to control erosion and speed revegetation are also useful. Fish spawning grounds and bottom feeding grounds are particularly vulnerable to destruction by sediment in headwater areas of streams. If a stream cannot be adequately protected during the mining operation, then a commitment must be made to reclaim and probably restock it as part of the overall reclamation plan.

3. Salvage Operation and Road Construction

Prior to mining or overburden dumping, merchantable timber should be cleared leaving a clean edge to which revegetation can be tied. Where overburden is placed on steep, treed slopes, the stability of the dump can be reduced as the trees decay and produce a slippage surface. Clear-cutting with proper cleanup of the refuse leaves the land in the most suitable condition for mining, dumping or road construction. These salvage operations should be done before construction. A mixture of topsoil, roots, slash and small stumps should be salvaged and used to cover dumps or abandoned haul and access roads.

Haulage and access roads are usually built and located with less thought to the land disturbed than to the efficiency of the mining operation. Exploration parties are often the least cognizant of proper road

construction since they only make short term use of the roads they build. However, these roads usually are apparent for many years after the exploration is completed unless they are reclaimed. A limited number of well built and maintained roads with culverts provide valuable access to a new area, but all other roads and exploration disturbances should be revegetated. Where necessary, backfilling, contouring or scarification should precede revegetation.

4. Overburden Management

The preferred technique for producing mass stability and a suitable topography of surface mined land is to backfill as many pits as possible with overburden from other areas. This technique has been more the exception than the rule in Alberta especially in rugged terrain and where pits are widely separated. Backfilling is planned overburden management; end-tipping rarely is.

If overburden dumps are required, they should be constructed like an earth dam, from the bottom up, rather than by end-tipping into a valley down a steep slope. When overburden is placed on the bottom first, it becomes compacted and settles as the dump increases in height thereby increasing its stability and reducing its volume. As material is added a bench or contour is left around the edge of the dump at about every 50 ft. of vertical lift. These benches are used to place topsoil and to hydroseed the slope below. Revegetation proceeds uphill as each lift is completed to keep the area of exposed overburden to a minimum.

This method of overburden management may be somewhat more expensive than end-tipping but it has many advantages from an environmental point of view.

Another way of handling overburden is end-tipping to the angle of repose (about 70 percent) and grading to a slope of less than 50 percent. If this is done adequate space must be left at the toe of the dump to allow for the reduction of the slope. The main disadvantages of this technique are the length of the slopes that are produced and the delay in stabilization and revegetation that it involves.

D. RECLAMATION PROCEDURES

1. Stability and Topography

Proper overburden management yields a stability and topography that is suitable for revegetation in accordance with the land-use objectives of the reclamation plan. Mass stability depends basically upon the mechanical properties of the overburden material, the physical structure of dumps and the drainage patterns within the area. Less is known of the effects of weathering and settling upon dump stability, but these processes increase the dump's density water holding capacity, and provide increased stability by increased granular pressure. Water saturation of a fine-grained mass on slopes favors creep or sliding. These and other factors must be borne in mind in a stability analysis of dumped sandstone and shale during the planning and engineering design processes. All dumps should have mass stability before revegetation is begun.

Slopes greater than 50 percent are very difficult to revegetate with present techniques, although slopes of 60-70 percent do occur naturally and can have a stable vegetative cover. The main constraints upon slope reduction are its cost and the greater land area required to accommodate the same amount of material. Further research is required to determine if short (approx. 100 ft.), steep (60-70 percent) slopes can be surface stabilized effectively and at a cost that is less than

that of grading to a 50 percent slope. Such procedures are used in Europe but have not been tested in Alberta. In the absence of these methods, one is forced to recommend that all slopes be graded to 50 percent or less if for no other reason than to facilitate revegetation.

Highwalls represent the most abrupt changes in topography left by surface mining without backfilling; they remain as a nearly vertical rock face of limited aesthetic value, and of some hazard to wildlife and people. An effective way of removing the highwall from the landscape is to form a lake in the adjacent pit, but this requires a suitable surrounding topography and water supply. For many pits, however, the cost of providing suitable water and dams may be less than that of backfilling, and there is a possibility of providing a recreational facility. Again, further research is required to determine other ways of handling highwalls, since it is questionable whether any completely exposed highwalls should be left after reclamation is finished.

Surface topography or micro-topography is of particular importance to rapid plant establishment. A rough surface provides more protected micro-sites for seed germination and seedling establishment than does a smooth or packed surface. Because of this, no attempt should be made to smooth or pack spoil material after grading once large boulders and trash are buried. Hard, impermeable surfaces require scarification. Harrowing, packing or washing in the seed are necessary surface treatments on loose, weathered or excessively rocky surfaces. Experiments have demonstrated

that the initial distribution of grasses and legumes on overburden is determined largely by the distribution of suitable micro-sites for germination and early growth.

2. Revegetation

Revegetation should be considered a two-step operation. The first step is establishing a ground cover of grasses and legumes to control erosion and act as a nurse crop for secondary vegetation. The second consists of a gradual change of the vegetative cover toward those species that best meet the land-use objectives of the reclamation plan. The first step should be initiated each fall on all areas that have a suitable stability and topography for revegetation and are not part of the active mining operation. Hydroseeding techniques can be used effectively since they are well adapted to the rugged terrain and variable surface topographies common to mined-land.

The second phase of revegetation will take several years for completion and will involve both seeding and planting by techniques suited to the species involved. Some secondary vegetation such as trees and shrubs can be included in the initial seeding step but many will require subsequent plantings. The choice of species and establishment techniques for a given location cannot be generalized and they are best determined by vegetation surveys of nearby undisturbed and disturbed land, operational research trials and well chosen land-use objectives. As with other

aspects of reclamation the details of revegetation and landscaping are sufficiently complex to require reclamation specialists to ensure their successful completion.

3. Streams and Small Lakes

Portions of streams within the "active mining center" that were frequented by fish prior to mining and have deteriorated due to mining, must be reclaimed to reform spawning grounds and provide protection and food for fish. Trout stream quality in particular is dependent upon favorable watershed conditions in which land and streambank erosion is controlled. Any stream improvement project associated with reclamation should include a watershed and stream habitat survey and be co-ordinated with provincial fishery management plans. Improvement techniques may involve treating channels, streamsides or watersheds to maintain regulated streamflow, water quality, and aquatic habitats. A suitable mosaic of pools, riffles and stream meanders are necessary for optimum fish production.

The creation of small lakes may be a part of the reclamation plan, or existing lakes may deteriorate due to surface mining and associated water use. Therefore, a lake improvement project may be necessary. Plans for new impoundments or lake level improvements require a careful, individual analysis including a multiple-use survey, impact report, description of the physical features of the site and an evaluation of biological and

water quality factors. Existing lakes can be improved by providing spawning grounds, adequate water depth and protection for fish, and by regulating fish and aquatic plant populations. Very small or shallow lakes should not be planned as permanent landscape features outside the alpine and subalpine zones since they are prone to rapid eutrophication, to production of aquatic plants and insects and provide limited opportunities for boating and other recreational uses.

4. Visitor-use and Recreational Facilities

When the land-use objectives of the reclamation plan include recreation or visitor-use, then facilities should be provided for: viewpoints, boating, swimming, fishing, camping, hiking, hunting, skiing or other outdoor activities that are consistent with the amenity values of the area. These projects should be co-ordinated and cost-shared with provincial agencies to ensure a unified regional development of recreational facilities. A good example of where a plan for these facilities should be part of reclamation is in the vicinity of a lake which already has developed parks, summer dwellings and boating facilities and is near to an urban center.

5. Reclamation costs

Each reclamation plan is unique, must be costed separately and may differ widely in cost depending on its objectives. However, costs can be separated by operations as follows:

a) planning and supervision, including surveys, land-use and impact studies;

b) topographic changes such as grading, contouring, back-filling and drainage control;

c) revegetation;

d) stream and lake improvement;

e) special facilities such as for recreation (cost-shared with the Province).

These costs do not include those monies spent on environmental protection during the exploration or operational phases of the mining.

Each of these five cost factors could range in value from several hundreds to several thousands of dollars per acre, and there is limited information for Alberta upon which to base more accurate estimates. Operational research and pilot reclamation programs may be necessary to project the total reclamation costs over several years for a surface mine of hundreds of acres. The standards set by legislation will also have a bearing upon costs. Since reclamation of mined out areas should proceed during active mining of other areas, reclamation costs can best be viewed as part of the operational costs of the mine as a whole rather than a debt to be paid in the future. In this way the economic feasibility of the whole operation can be assessed as it proceeds. Bonding and "setting aside" funds for reclamation are poor substitutes for actually doing it, even on a small scale.

E. ENVIRONMENTAL IMPACT OF RELATED SURFACE DISTURBANCES

1. Quarries and Gravel Pits

Little attempt has been made in Alberta to reclaim quarries and gravel pits probably because of their small area and scattered location. These smaller land disturbances should be dealt with mainly from an aesthetic point of view. When a gravel pit breaks the continuity of the roadside landscape, it is as aesthetically displeasing as a similar area of junk cars. Care should be taken therefore to backfill, contour and revegetate all quarries, pits, and other small land disturbances that are visible from scenic routes.

2. Rights-of-way and Construction Sites

Final contouring, drainage and revegetation are common practices on most major construction projects such as dams, highways, canals and pipelines. Hydroseeding has probably been used on roadsides more than anywhere else. Highway and pipeline reseeding is usually limited to simple mixtures of grasses and legumes, however, in many places a greater variety of plants would be more desirable and natural. For example, seeding bromegrass and alfalfa in a park detracts from its natural beauty because such plants are not ordinarily found there. Greater attention should be paid to landscaping techniques in these cases.

3. Tar-sand Extraction

The present and proposed tar-sand extraction operations along the Athabasca River will have an environmental impact of a magnitude and

complexity as great as coal mining in the foothills if a surface mining technique is adopted throughout the whole tar-sand area. Although coal and overburden yield sediment and some chemicals upon weathering, the bitumen, process chemicals and extraction products of a tar-sand operation are biologically more toxic than coal or overburden. Also the high groundwater levels in this region and the need for the use and wasting of large volumes of water will make the job of environmental protection more difficult. Most of the statements made in this brief apply to tar-sand extraction operations but they do not cover the hydrologic and chemical complexities of the problem. Research should be initiated immediately to assess the full environmental impact of this industrial development.

F. RECOMMENDATIONS FOR PROPOSED SURFACE RECLAMATION LEGISLATION

1. Introduction

Although the focus now is upon disturbances from surface mining of coal, it is assumed here that "surface disturbance" will include any major removal or disruption of land, vegetation or water surfaces.

It is also assumed that reclamation of surface disturbances must take place within the context of land management and land-use zoning. Existing Alberta legislation, through Sec. 15 of The Department of the Environment Act, 1971, already provides for the co-ordinated and regulated development and use of designated areas in the Province.

Another general feature of these recommendations is that the legislative approach to reclamation should be preventative rather than punitive. This in itself stresses the importance of reclamation taking place within the context of planned land-use and "land management zones".

In preparing this legislation it will be important to contact reclamation administrators in other regions of North America who have experience in both the consequences of non-regulated surface mining and the introduction of stringent reclamation regulations. Some argue that regional variations in climate, topography, geology, vegetation or the chemistry of the coal make comparisons of reclamation techniques between regions invalid, but there are fewer regionally unique features when it comes

to matters of planning, administration of regulations or inspection of reclamation areas.

There is no attempt here to draft specific clauses that should be a part of surface disturbance legislation in Alberta. This is a task for the experts - the legal draftsmen. However, several provisions that should be considered in the formulation of this new legislation are listed below.

2. Some Recommended Provisions

a. Statement of policies and goals

Alberta statutes are not uniform in their approach to a statutory statement of purposes, policies and goals with respect to environmental matters. The Wilderness Areas Act is an example of a statute with a preamble that sets out environmental policies and goals; the Environment Conservation Act and the Department of the Environment Act do not set down any such policies or goals. Any statute to provide for the reclamation of surface disturbed lands should begin with a clear statement of purpose, policies and goals. If this is done, the public has important criteria by which to judge the effectiveness of the statute, and has a basis for review of specific administrative decisions made under provisions of the Act.

It is important that statutes such as the Right of Entry Arbitration Act, do not have over-riding authority over the proposed surface reclamation legislation in matters of environmental management.

b. Definition of reclamation

The proposed legislation should avoid a restrictive definition of "reclamation". The full range of potentially deleterious effects should be considered, such as damage to vegetation, wildlife habitats, land surfaces, soil, water bodies, aquatic habitats, hazards to public health and property, or reduction of aesthetic and historical values. Reclamation should be viewed broadly to include the amelioration or prevention of any of these deleterious effects. In the case of disturbances from mining, statutory definitions should make it clear that the legislation covers all mining activities including camp clean-up, drilling sites, roads, exploration trenches and waste dumps from underground mining.

c. Unquantified amenities

In the introductory economic discussion of this brief it was pointed out that long-term environmental consequences and costs external to the actual mining operation provide part of the rationale for public regulations. Consideration must be given to a statutory provision that requires all agencies concerned with reclamation planning to identify and develop procedures that "ensure that presently unquantified environmental amenities and values are given appropriate consideration in decision-making along with economic and technical considerations"[1].

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[1] The precedent for statutory entrenchment of such an administrative procedure is to be found in Sec. 102 of the U.S. National Environmental Policy Act.

d. Dual level of regulation

Two levels of regulations are recommended; those that are applicable to all forms and all geographic locations of surface disturbances, and those that are applicable only to particular sites within designated "land management zones". With this basic statutory provision, regulations would then differentiate between those conditions that are common to the whole Province and those that vary geographically. The latter geographic variations should be recognized by the imposition of designated "land management zones" such as the plains, foothills, subalpine, alpine or boreal ecological areas. Further flexibility could be build into the regulatory system by giving enforcement officers authority to impose upon permits special terms and conditions that take into consideration special environmental conditions on a specific mine site. One model for this approach is the 1971 Northern Land Use Regulations established under the 1970 Amendments to the Territorial Lands Act.[2]

e. Pre-planning for reclamation

A major weakness of some existing reclamation legislation is the lack of a statutory requirement for pre-planning and continual reclamation. There is a tendency for reclamation to be considered only towards the end of a mining operation. Particular attention must be given to regulations that would minimize environmental damage both during and

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[2]R.S.C., Ch. 48 (1st Suppl.) 1970.

immediately after the mining operation. Such regulations should seek to ensure prompt stabilization of soil, establishment of cover crops, and reestablishment of fish and wildlife populations. This implies that inspection must not be limited to a final step in the operation but must be a regular activity through the entire surface-mining process.

f. Burden of proof on resource user

Legislation should ensure that the burden of proof in respect to establishing environmental protection rests upon the party creating the surface disturbance and not upon the enforcement agency.

The concept of "innocent until proven guilty" has developed in common law with respect to persons. It is only by extension that we have applied this same concept, perhaps innocently, to things, processes, chemicals and excremental industries. That this extension has resulted in poor management of common resources is readily evident. There should be a reversal of this traditional approach.

British Columbia's new reclamation legislation and procedures go part way toward this recommendation by requiring the mining company to submit a report stating its reclamation intentions. The first report from the company should include proposals for operational studies to be carried out during the first year of the permit. An annual reporting, with

annually revised research plans, continues until there is sufficient information to formulate a reclamation plan. When the reclamation plan is submitted and approved a permit is granted[1]. In British Columbia, responsibility for action lies with the resource user during the early phases when a reclamation plan is being formulated, but it remains unclear where responsibility would lie for settlement of later disagreements over the nature and extent of environmental damage. Alberta legislation should be planned to place the burden of proof on the resource user even more fully and clearly than the current British Columbia legislation appears to do.

g. Optional contractual agreements

Where the number of surface mining operations is small, it is possible for the administering agency to deal with each operator on an individual basis. This arrangement can develop to the point that the mining industry recognizes that in effect the producer enters into an agreement with the administering agency to protect the environment before the project begins. This arrangement is often handled by a permit system but there would be advantages if legislation provided at least an option to allow the agreement to become contractual[2]. There are

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[1]This summary of British Columbia's 1970-71 procedure is based on an unpublished report by J.L.E. Hogg, 1971, "The importance of institutional and environmental factors in the formulation of a policy for the reclamation of mined lands in British Columbia". Paper presented at 15th IUFRO Congress, Gainesville, Florida.

[2]For a discussion of the contractual alternative see "Mined-land reclamation in the Western States - a brief look", Hard Minerals Committee, Natural Resources Section, American Bar Association, Nat., Res. Lawyer IV: 552, 1971.

legal advantages of a contract in terms of responsibility, liability and enforcement. A further advantage of a "contract to reclaim" is that it could provide a flexible alternative for those situations where, under a permit system, compliance with mandatory reclamation regulations may be impractical or impossible. This approach would require both parties in the contract negotiations - the operator and the administering agency - to possess a considerable degree of reclamation expertise. The contractual approach, if adopted, should not be made mandatory until proven reclamation methods are developed. In the interim, it is recommended that there be a review of statutory mechanisms that would allow reclamation to be undertaken by either the permit system or the contractual agreement.

h. Boundary of operations

A legally definable boundary should be drawn around the "active centre of mining" at any given time. This boundary would be used to mark out control points for enforcement of environmental quality standards. All downstream or downwind effects would be contained within this boundary. If environmental quality control is required inside of the boundary it should be administered by the agency that has major regulatory powers for other integral parts of the mining operation, such as mine safety. This procedure would allow the co-existance of mining operations and stringent environmental quality standards because the standards would be applied only up to the boundaries of a zone that would surround the centre of concentrated surface disturbance. If this

approach were adopted there would need to be provision for some form of dual jurisdiction to allow separate administration of regulations within and outside a legally definable "centre of operations". Such a provision should be designed so that it does not interfere with the needs outlined in item (e) above, where it was stressed that reclamation steps must be an integral part of the entire mining process. A precedent for this form of administrative procedure is found in the methods proposed for administration of the 1971 Northern Land Use Regulations. There, resource management officers have jurisdiction over all land-use activities associated with petroleum exploration up until a well is established; then an engineer, under a different statutory authority, assumes responsibility for environmental protection on the drilling site during the term of the drilling; enforcement of final clean-up of the site is shared by the two officers. In the context of Alberta reclamation, administrative analogies could be the Energy Resources Conservation Board which might have jurisdiction comparable to the engineer on the northern well site and a newly structured "Division of Reclamation" within the Department of the Environment which could have jurisdiction comparable to that held by the northern resource management officer.

i. Public hearings

Existing surface reclamation legislation in Alberta, where it does refer to enquiries, indicates that an enquiry is discretionary rather than mandatory. This feature of the legislation could be strengthened by

requiring public hearings to precede major resource-use allocations within designated "land management zones". The purposed statute should define the circumstances for which a public hearing would be mandatory. Such a provision could also require statutory guarantees of availability to the public of any detailed environmental impact statements prepared by consultants or agencies of Government[1].

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[1] For an example of such a statutory provision see Sec. 102(c) of the U.S. National Environmental Policy Act.

G. SUMMARY

A. Basic Economic Analysis of the Coal Mining Industry in Alberta.

1. From the viewpoint of the mining industry, surface techniques offer real advantages: a) they make possible the recovery of deposits which, for physical reasons cannot be mined by underground methods; b) they provide safer working conditions; c) they usually result in more complete recovery of the deposits; and d) most significantly, they are cheaper in terms of unit costs.
2. Albertan benefits are for the most part measured by direct and indirect employment opportunities, revenues generated for provincial and local governments, and the kilowatts of low cost electricity which provide a source of energy for homes and businesses.
3. Although employment opportunities are created by the presence of the coal mining industry and its related activities, it is not a labour intensive industry.
4. Allocation of areas for industrial activity in combination with other land-uses can be effectively determined by sound and unbiased planning which considers equally all resources, whether quantifiable in economic terms or not.

B. Co-ordination of Surface Coal Mining, Environmental Protection and Reclamation.

1. Before there is any development for coal or other minerals in

a particular region it should be determined whether there is some other over-riding land-use for which the area is better suited, and whether that use would preclude or limit surface disturbances.

2. All land is watershed and to some degree aesthetic and most lands support wildlife. Some land contains fish habitat and some has commercial value for timber or agricultural crops.
3. Ground water flow patterns can be disrupted by strip mining. Because pre-mining groundwater flow patterns can not be expected to reoccur after reclamation, these alterations should be considered as irreversible in the foothills and mountain areas.
4. Coal-bearing areas include lands that support aspen and/or grassland vegetation. In western Alberta these are productive and critical ranges for numerous big game and upland game bird species as well as many equally important non-game species. Notable of the "game" species are mule deer, elk, bighorn sheep, ruffed and sharp-tailed grouse and to a lesser extent mountain goats, caribou, moose, white-tailed deer, Franklins and blue grouse, and white-tailed ptarmigan. The streams and lakes of western Alberta abound in a rich and varied aquatic fauna including a diverse and abundant fish population. Numerous fur-bearing species are located within the coal-belt as well as several rare and endangered wildlife species such as the mountain caribou, mountain goat, bighorn sheep, wolf, grizzly and cougar.

5. Wild ungulates are forced to winter on 10 percent or less of the total mountainous area, with many winter ranges supporting wild ungulate densities of 25 to 100 animals per square mile of range. Open grasslands and aspen pastures comprise over 75 percent of this confined winter range.
6. Requirements for industrial participation in impact studies and operational research in Alberta would hasten the development of environmental protection and reclamation methods.

C. Environmental Protection During Surface Exploration and Mining for Coal.

1. Since both physical and chemical water quality will be affected by surface mining, a water quality monitoring and control program is an integral part of environmental protection during surface coal mining.
2. The water quality parameters most commonly altered by coal mining are suspended solids, turbidity, color, iron, manganese, organic carbon, nitrates, phosphates and alkalinity.
3. Small lakes are quite vulnerable to accelerated eutrophication and need protection from sediment and inorganic chemicals that can leach from the surrounding land when it is disturbed, become concentrated in the lake, and cause algal and aquatic plant blooms.
4. The prime way of combatting soil erosion is by keeping the area of disturbed, unvegetated land to a minimum. Drainage control and sediment catch basins must be used until revegetation is completed.

5. The preferred technique for producing mass stability and a suitable topography of surface mined land is to backfill as many pits as possible with overburden from other areas.

D. Reclamation Procedures.

1. Proper overburden management yields a stability and topography that is suitable for revegetation in accordance with the land-use objectives of the reclamation plan.
2. Slopes greater than 50 percent are very difficult to revegetate with present techniques, although slopes of 60-70 percent do occur naturally and can have a stable vegetative cover. Further research is required to determine if short (approx. 100 ft.), steep (60-70 percent) slopes can be surface stabilized effectively and at a cost that is less than that of grading to a 50 percent slope.
3. An effective way of removing the highwall from the landscape is to form a lake in the adjacent pit, but this requires a suitable surrounding topography and water supply.
4. A rough surface provides more protected micro-sites for seed germination and seedling establishment than does a smooth or packed surface.
5. Revegetation should be considered a two-step operation. The first step is establishing a ground cover of grasses and legumes to control erosion and act as a nurse crop for secondary vegetation. The second consists of a gradual change of the vegetative cover toward those species that best meet the land-use objectives of the reclamation plan.

6. The choice of species and establishment techniques for a given location cannot be generalized and they are best determined by vegetation surveys of nearby undisturbed and disturbed land, operational research trials and well chosen land-use objectives.
7. Portions of streams within the "active mining center" that were frequented by fish prior to mining and have deteriorated due to mining, must be reclaimed to reform spawning grounds and provide protection and food for fish.
8. The creation of small lakes may be a part of the reclamation plan, or existing lakes may deteriorate due to surface mining and associated water use. Therefore, a lake improvement project may be necessary.
9. When the land-use objectives of the reclamation plan include recreation or visitor-use, then facilities should be provided for: viewpoints, boating, swimming, fishing, camping, hiking, hunting, skiing or other outdoor activities that are consistent with the amenity values of the area.
10. Each reclamation plan is unique. Operational research and pilot reclamation programs may be necessary to project the total reclamation costs over several years for a surface mine of hundreds of acres.
11. Since reclamation of mined out areas should proceed during active mining of other areas, reclamation costs can best be viewed as part of the operational costs of the mine as a whole rather than a debt to be paid in the future.

E. Environmental Impact of Related Surface Disturbances.

1. Care should be taken to backfill, contour and revegetate all quarries, pits, and other small land disturbances that are visible from scenic routes.

2. Most of the statements made in this brief apply to tar-sand extraction operations but they do not cover the hydrologic and chemical complexities of the problem. Research should be initiated immediately to assess the full environmental impact of this industrial development.

F. Recommendations for Proposed Surface Reclamation Legislation.

1. A general feature of these recommendations is that the legislative approach to reclamation should be preventative rather than punitive.

2. Any statute to provide for the reclamation of surface disturbed lands must begin with a clear statement of purpose, policies and goals.

3. The proposed legislation should avoid a restrictive definition of "reclamation". The full range of potentially deleterious effects should be considered, such as damage to vegetation, wild-life habitats, land surfaces, soil, water bodies, aquatic habitats, hazards to public health and property, or reduction of aesthetic and historical values. Reclamation should be viewed broadly to include the amelioration or prevention of any of these deleterious effects.

4. Consideration must be given to a statutory provision that requires all agencies concerned with reclamation planning to identify and develop procedures that "ensure that presently unquantified environmental amenities and values are given appropriate consideration in decision-making along with economic and technical considerations".
5. Two levels of regulations are recommended: those that are applicable to all forms and all geographic locations of surface disturbances and those that are applicable only to particular sites within designated "land management zones".
6. Particular attention must be given to regulations that would minimize environmental damage both during and immediately after the mining operation.
7. Legislation should ensure that the burden of proof in respect to establishing enviornmental protection rests upon the party creating the surface disturbance and not upon the enforcement agency. A report from the company should include proposals for operational studies to be carried out during the first year of the permit.
8. It is recommended that there be a review of statutory mechanisms that would allow reclamation to be undertaken by either the permit system or the contractual agreement.
9. If a legally definable boundary were adopted, there would need to be provision for some form of dual jurisdiction to allow separate administration of regulations within and outside a legally definable "centre of operations".

10. The purposed statute could define the circumstances for which a public hearing would be mandatory.

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