ATHABASCA TAR SANDS DEVELOPMENT

ENVIRONMENTAL IMPACT STATEMENT MATRIX

PHYSICAL & CHEMICAL CHARACTERISTICS

May 18, 1973

Standards & Approvals Division
Department of Environment
Edmonton, Alberta

SUMMARY

The methodology of environmental impact analyses incorporates the principle of subjective assessment of the impacts of the separate actions which comprise the project upon various factors of the environment. The significant factors relating to effects on the physical and chemical characteristics of the northern Alberta environment as a result of potential oil sands development in the Athabasca tar sands were documented according to the "Procedure for Evaluating Environmental Impact" - Geological Survey Circular 645. The text of this impact report was based on the sum of magnitude and importance vectors being equal to or greater than 5 for any specific sector of the physical and chemical environment. This report and possible computer data adaptation may provide for additional summation and recommendation of specific actions incurred by oil sands development as these proposals further relate to biological and cultural aspects of the environment.

ACKNOWLEDGEMENT

Participation by various members of the Department of the Environment and Research Council of Alberta to determine numerical ratings of the environmental impact vectors relating to effects on the physical and chemical characteristics of the environment resulting from oil sands development proposals was appreciated. The submissions of the following individuals assisted the preparation of this consolidated report:

R. Green	Research Council of Alberta
R. Deeprose	Department of Environment
H. A. Kerr	Department of Environment
B. Boyson	Department of Environment
S. Dobko	Department of Environment
P. Shewchuk	Department of Environment

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INTRODUCTION

The environmental impact assessment matrix is a simple way of summarizing which impacts are considered of greatest significance. It is a checklist or reminder of the full range of actions and impacts and is aimed at separating, as far as possible, factual information on magnitude of each type impact from the more subjective evaluation of the importance of the impact. The most significant vectors (magnitude and importance equal or greater than 5) relating to the physical and chemical characteristics of the environment to be affected by oil sands development of the Athabasca tar sands are documented herein.

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

1. EARTH

1.a MINERAL RESOURCES

B. (a, b, c, d, e, f combined) (6/8) - Urbanization

Growth of the Town of Fort McMurray is inevitable with further oil sands development. It would be desirable to limit expansion of the townsite to those areas not underlain by oil sands. If new townsites are planned, these should be located outside the mining area in a place where the oil sands are absent or poor in quality. In the future it may be feasible to develop new townsites on the mined out areas.

C. b (9/9) - Surface Excavation

In the mineable area, surface excavation is the normal method of extraction and will result in almost complete removal of the oil resource. Outside the mining area, surface excavations will probably have little effect on the availability of the underlying mineral resources.

Surface excavations for purposes other than strip mining may improve the economics of mining in these areas by reducing the thickness of overburden covering the oil sands.

D. (e, f, k, o combined) (9/6) - Mineral Processing

These facilities may, if located over mineral resources, temporarily prevent their exploitation. However, as most of these facilities are depreciable, they can be removed if exploitation of the underlying mineral resources is desired.

E. c (6/2) - Strip Mining Rehabilitation

The effect of strip mine rehabilitation is mainly on the quartz sand and heavy mineral tailings which are returned to the mining area after extraction of the bitumen. Rehabilitation inhibits easy access to these mineral resources.

H. c.j (6/2) - Emplacement of Tailings, Spoil, and Overburden

In some areas at least, this may significantly inhibit mineral resource development. For example, the initial 9 square miles of Syncrude tailings ponds will make it difficult to develop subsequently the bituminous sands under that area. The effect of liquid effluent discharge is similar.

1.b <u>CONSTRUCTION MATERIAL</u>

C. <u>b (5/2) - Surface Excavation</u>

Strip mining of the oil sands will initially expose construction materials such as sand and gravel but will ultimately result in their burial beneath the oil sands tailings.

E. <u>a, c, d (5/1) - Strip Mining Rehabilitation</u>

This will result largely in burial of potential construction materials, i.e,. sand and gravel.

1.c <u>SOILS</u>

Before considering the specific environmental factors affecting the soil, a precise definition of the entity "soil" should be given, along with the major processes governing its formation.

Different professional and non-professional people give a different meaning to the entity "soil". To engineers it is often the entire layer of unconsolidated material above the bedrock. The agrologist, however, calls this regolith and considers as soil, the upper and biochemically weathered portion of the unconsolidated surface material, which is distinguished from the material below by: (1) a relatively high organic matter content; (2) an abundance of roots and soil organism; (3) more intense weathering; (4) the presence of soil horizons and (5) a change in porosity, permeability and degree of leaching.

The type of soil, which will be formed depends on the factors regulating the soil forming processes. Under natural conditions there are five of these:

(1) Climate - climate is the major regulating factor. It influences the degree of weathering and the type of living organisms.

(2) Parent material (its physical, chemical and mineralogical composition).

(3) Living organisms (especially vegetation).

(4) Topography.

(5) Age - length of time that the material has been subjected to weathering.

The environmental impact will in general not effect climate, but will one or more of the four last factors. If the environmental impact is of a short duration, eventually a similar soil as before will be formed. But, when the impact continues a soil type could develop which will be somewhat different from the previous one. The degree of variation will depend on the kind of environmental factor.

Some of the major environmental actions will be commented on in the following sections:

B. a to e (7/3) - Urbanization

Urbanization alters the parent material, living organisms and topography of a soil. Their effect upon the soil is in general lasting and detrimental and consequently, a different, less valuable, type of soil can be expected afterwards. However, the extent of these actions are in general very localized, and therefore, their importance is small.

C. b (7/2) - Surface Excavation

Surface excavation has an effect similar to B. a.

E. c (5/3) - Strip Mining Rehabilitation

F. a (5/1) - Reforestation

Reforestation is of great importance to the soil in localities where it prevents soil eroding processes, which expose unweathered, infertile soils and which result in gullies and ravines. Because the latter covers very few acres its importance is considered small.

G. k (6/1) - Pipelines

H. c (6/2), e (4/1) - Emplacement of Tailings

Emplacement of tailings, result in a layer of unconsolidated material, which is considered poor from an agrologist's point of view, and possibly, also from an engineer's point of view. The material possesses, in general, few of the characteristics inherent to the soil of that area.

H. m (4/6) - Stack and Exhaust Emissions

Soils in the area at present are acidic with pH values of 6. The base line levels of sulphur and trace metals in the surrounding vegetation and soil may be expected to increase.

J. b (5/1) - Spills and Leaks

J. c (5/1) - Operational Failures

1.d LAND FORM

Before outlining the various actions which have an environmental impact on land forms one of the fundamental concepts of geomorphology should first be considered, namely: "Geomorphic processes leave their distinctive imprint upon land forms, and each geomorphic process develops its own characteristic assemblage of land forms". According to this concept then, any action which alters, or accelerates a particular geomorphic process or group of processes can be considered as having an environmental impact. Based on this reasoning almost every action will have some environmental impact. However, once the magnitude and importance of the impact is considered many of the proposed actions can be eliminated. Those actions which are significant with regard to land forms are as follows:

B. a (5/1) - Urbanization

C. b (7/2) - Surface Excavation

E. c (9/3) - Strip Mining Rehabilitation

This action is probably the most important of those outlined as having significant environmental impact on land forms. In order to be an economical operation strip mining must be carried out on a relatively large scale. Secondly, the rehabilitation aspect will create definite changes in the topography and geology of an area and subsequently alter the existing geomorphic processes. The magnitude of impact has, therefore, been rated 9. Since the action is carried out on a more or less local basis the importance has been assigned a value of 3.

H. c (6/2) - Emplacement of Tailings

1.f UNIQUE PHYSICAL FEATURES

A. f.g (7/1) - Alteration of Drainage

Drainage modification will certainly result in destruction of some locally unique physical features. However, this is not likely to be a matter of major concern.

C. b (9/2) - Surface Excavation

Surface excavation will lead to destruction of all local physical features in the mining area. Again, the absolute significance of this is not likely to be great.

E. a.c.d (9/9) - Strip Mining Rehabilitation

This is considered to be of major significance in that it offers the opportunity to create or recreate unique and distinctive physical features in the mined-out areas. To date, the only reclamation plans known propose only a geometric configuration of a landscape and have no conceptual architectural or landscape design features incorporated.

H. c (6/2) - Emplacement of Tailings, Spoil, and Overburden

The weighting factor of 6/2 refers to the impact of placing tailings spoil and overburden in such features as lakes, ponds, and streams in the mining area. Its impact is comparable to that of alteration of drainage. However, in terms of landscape design subsequent to mining, the importance of proper placement of overburden and tailings is certainly as great as that of strip mine rehabilitation. The weighting factor given to this category may, therefore, deserve a higher rating.

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

2. WATER

2.a SURFACE

A. f (8/3) - Alteration of Drainage

Alteration of drainage and river control can produce very high impact in that streams may be rerouted but the type of drainage alteration proposed is of local importance only - changing the patterns of water flow on the leased areas.

B. (a, b, c, d, e, f) (6/1) - Urbanization

Urbanization with its accompanying hard surfacing and ditching affects infiltration of precipitation and location of water courses (former streams are displaced by ditches) has a relatively high impact but the effect is limited to the immediate area.

C. b (7/2) - Surface Excavation

The stripping of the surface material destroys the media through and over which precipitation flows to stream channels and in fact produces a huge "bowl" for the interception of all precipitation. As with A (e and g) the local impact is high but the areal extent of such excavations will not be large enough to have a wide ranging effect.

C. f (5/4) - Clearcutting

Clearcutting can have a moderately high effect on water supply as the absence of water using plant life makes a greater volume available for run-off. Clearcutting is likely to extend over huge areas at once so the effect could be regional in extent.

D. (e, f, k, o) (7/3) - Mineral Processing

Considerable amounts of water are necessary for processing requirements and if local supplies (other than a large river are used) the impact on the particular source could be quite dramatic, on the other hand, the effect is limited to the region under development.

E. (a, c, e) (8/3) - Strip Mining Rehabilitation

Comments which were made under A (f) and C (b) apply here equally. Any restructuring of the land surface and drainage paths will affect the supply of surface water at a point but the effect will be limited to the worked-over region.

F. a (5/4) - Reforestation

See comments under E (f).

H. c (7/2) - Emplacement of Tailings

Essentially the same reasoning as in E (a, c, e). The topography and infiltration of the land surface is being altered.

H. (j, k, n) (4/2) - Liquid Effluent Discharge

Any discharge of water is important at the point of discharge but the effect is local in nature. Assuming discharge will be back into the same stream (or basin) from which water for processing was withdrawn.

2.c UNDERGROUND

There are three basic components of the groundwater regime which must be considered before an evaluation of environmental impact can be made. These include the distribution of groundwater, movement of groundwater, and groundwater chemistry. The hydrogeologic environment of an area, on the other hand, consists of three other aspects of the region - topography, geology, and climate. These three aspects act simultaneously to control the groundwater regime resulting in a unique and quantitative relationship between the groundwater regime and the hydrogeologic environment.

Any action which alters the groundwater regime directly, or indirectly by changing one or more components of the hydrogeological environment, may be considered as having an environmental impact on the groundwater resources. The magnitude and importance of impact will depend on the nature of the existing components of the hydrogeological environment and groundwater regime and, secondly, on the effect the proposed action will have on these various components.

Following is a list of proposed actions which may cause some significant environmental impact with regard to the groundwater resources. The asterisk (*) indicates the most significant proposed actions (i.e., where total assigned value - magnitude plus importance is 10 or greater).

A. e (4/1) - Alteration of Groundwater Hydrology

B. a (6/1) - Urbanization

C. b (9/3) - Surface Excavation

Surface excavations depending on the particular hydrogeological environment and nature of the excavation, can expose the groundwater resources to surface contamination and alter the occurrence of groundwater by non-essential removal.

This, in effect, changes two components of the groundwater regime, namely the distribution of groundwater and groundwater chemistry, and therefore, has been assigned a magnitude value of 9. Since the action is conducted on a local basis, importance is given a value of 3.

C. f(5/3) - Clearcutting and Lumbering

E. c (9/7) - *Strip Mining Rehabilitation

In this particular case, the topography and the geology are both altered to some degree. This in turn will effect the distribution of groundwater, the movement of groundwater, and to a small degree, the groundwater chemistry. Magnitude is rated 9, whereas, the action is considered province-wide and importance is, therefore, assigned a value of 7. Considered individually strip mining rehabilitation has probably the most significant environmental impact on the groundwater resources.

F. a (5/3) - Reforestation

H. b (6/1), c (9/3) - *Emplacement of Tailings

Similar to strip mining rehabilitation this action alters both the topography and geology, which in turn will effect the distribution and movement of groundwater. However, more important, is the pollution potential presented by this action. The degree of pollution will depend on the nature of the tailings. Whether or not they are of a noxious character, soluble in water, or any other factors which may alter the groundwater chemistry. The magnitude of this action has been considered sufficiently high and rated 9. The importance is considered local and given a value of 3.

H. j (5/3) - Liquid Effluent Discharge

J. b (4/4) - Spills and Leaks

2.d QUALITY

A. e (4/1) - Alteration of Groundwater Hydrology

To prevent pollution of adjacent water bodies and to restrict influences on groundwater movements, tailings embankments should be designed to minimize seepage. Maximum use should be made of recycled water and evaporation in order to obviate the need to discharge excess water from tailings ponds to a water course and help prevent excessive lowering of water tables after completion of the mining operation.

A. e.f (4/1) - Alteration of Drainage and Flow Modification

As a result of the number of small streams in the region that must be diverted around mining areas, increased erosion and sedimentation of the watershed may be expected. The effect on principle streams may be minimized by restricting open pit mining from the tops of stream valleys and ensuring that the diversions of certain streams is done in such a way that there is no increase in erosion activity or potential and that a desired level of aquatic life is maintained.

B. a to f (6/1) - Urbanization

The requirement for domestic use of water for the projected populace of the tar sands region will be much less than the industrial use. The total use of water at a production rate of one million barrels per day of synthetic crude oil plus water requirements of a population of 50,000 would be about 350 cubic feet per second (approximately 10% of the minimum Athabasca River flow). The domestic requirement would be 18.5 cubic feet per second. Water quality effects associated with the waste waters arising from domestic use may be minimized by implementation of current sewage treatment technology.

Secondary industry will be created by a substantial demand for supplies, spare parts, and services. The additional industrial growth will also represent a need for water supply and control of industrial waste materials.

C. b (3/3) - Surface Excavation

Residual oily waters collected in the open mine pit will require treatment before release to the watershed or may be recycled to the tailings pond.

C. f (3/3) - Clearcutting

The first step in the mining cycle is to remove the vegetation from the area to be mined. One million barrels per day will require the disturbance of approximately 2200 acres per year and erosion of stream beds and banks may be expected.

D. e to o (6/6) - Mineral Processing

The processing of one million barrels per day of synthetic crude oil will require 330 cubic feet per second of water. Water contaminants that are generated by the utilization of this water for extraction, upgrading, and power development will require control by the implementation of best available waste water treatment systems and current technology.

E. a to c (3/3) - Strip Mining Rehabilitation

Land reclamation procedures for tar sands mining are vague and do not provide adequate assurance for re-establishment of a satisfactory physical environment.

F. a (3/3) - Reforestation

The re-establishment of flora species will be contingent upon the ultimate soil and water conditions. A balanced vegetation pattern is desired to avoid domination by specific flora or fauna species.

H. c (9/5) - Emplacement of Tailings

The disposal of tailings from the hot water extraction process represents the most imminent environmental constraint. The possibility for pollution of the surface waters will exist wherever impounding of liquid tailings is permitted. The potential pollution of surface water is reduced when the liquid tailings are impounded within the mine pit and away from the banks of the Athabasca River. All of the local flora and fauna habitat will be destroyed wherever a tailings pond is established. The liquid tailings represent the most probably source of bitumen which could escape to surface waters.

H. j (9/7) - Liquid Effluent Discharge

Tailings ponds must be sufficiently sized to allow adequate clarification of water which can be recycled to the extraction plant. The principle concern of tailings impoundment or groundwater quality relates to possible seepage. The amount of seepage will be a function of the permeability of the walls and floor which constitute the tailings pond.

Waste waters originating from the bitumen upgrading section of the plant will require application of best practical treatment technology prior to release to the Athabasca River watershed. However, this liquid effluent can be returned to process if the tailings pond is sufficiently sized to permit recycling.

Each section of a tar sands plant (i.e., bitumen production, bitumen processing, power generation) emits liquid wastes. These effluents may be contained (tailings ponds) or treated (refinery waste water treatment technology).

The application of best treatment technology to liquid effluents from tar sands plants will prohibit the deterioration of water quality beyond the standards prescribed by the Alberta Department of the Environment.

H. i (5/5) - Septic Tanks and Municipal Waste Discharge

A population of 100,000 people in the tar sands area may be expected within 20 years or less. This projection could be higher if more secondary industries were encouraged to establish manufacturing plants. Provisions for proper control of waste waters originating from these activities will be required.

J. b (7/7) - Spills and Leaks

The Athabasca River or its related natural drainage basins could be polluted by any substantial leak in the pipeline movement of tailings slurry or synthetic crude oil product.

J. c (7/7) - Operational Failure

Industrial operations are susceptible to occasional emergencies, some of which could have impacts upon the environment. Such incidents include: accidental release of fluids, equipment failures, pipeline breaks. Operators of tar sands plants will be required to have contingency plans to cope with emergencies.

2.e TEMPERATURE

H. j (4/7) - Liquid Effluent Discharge

The generation of waste thermal energy in liquid effluents coincident with tar sands processing will cause a greater frequency, intensity, and area coverage and persistence of fogs. The increase in the ambient temperature of the Athabasca River will be dependent on the relative amount of thermal energy released to the watershed.

2.f RECHARGE

The rating factors for proposed actions affecting water recharge are similar to the numerical ratings for water - underground. The concerns are, therefore, similar.

2.g SNOW, ICE AND PERMAFROST

H. j (7/7) - Liquid Effluent Discharge

The increase in surface area of ice-free open water in the Athabasca River will be a function of the amount of thermal energy and liquid effluent released to the watershed.

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

3. ATMOSPHERE

3.a QUALITY

C. b (4/3) - Surface Excavation

After the overburden has been stripped and mining of the raw bitumen proceeds there will be a moderate increase in hydrocarbons in the atmosphere in the immediate vicinity of the open pits.

H. j (4/1) - Liquid Effluent Discharge

There would be a moderate amount of odorous gases emanating from the liquid effluent in the tailings and process water ponds. The sphere of influence would be very localized to the area adjacent to the ponds.

H. m (9/7) - Stack and Exhaust Emissions

The raw bitumen which is being refined contains about 5% sulfurous compounds. If the total amount of sulfurous compounds were emitted to the atmosphere the effects on both plant and animal life would be disastrous and widespread. However, the latest advances in process recovery will dramatically reduce the impact on the environment. The effects, though minimal, will still be over a large area. Other contaminants which will produce a moderate effect in a more restricted area are oxides of nitrogen, carbon monoxide, hydrocarbons and particulate matter including heavy metals.

J. a (7/4) - Accidents and Explosions

The chances of having an explosion are small but the results could be severe although not far reaching. An explosion could result in a slug flow of sulfurous compounds, smoke or particulate matter.

J. b (4/4) - Spills and Leaks

The adverse effects of leaks and spills should be moderate and the sphere of influence would be restricted to the "short term region" basis. Hydrocarbons would be the major contaminant involved.

J. c (7/4) - Operational Failure

The chances of having an operational failure are far greater than would be the possibility of having an explosion. Excessive contaminant emissions that could result from such a failure could have the same adverse environmental impact as would be realized from an explosion. Slug flows of short duration could result in affecting the short term regional area.

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

4. PROCESSES

4.a <u>FLOODS</u>

Flood potential is influenced by any action which serves to hasten or slow the concentration of run-off water following snow melt or rainstorm.

A. <u>f (8/3) - Alteration of Drainage</u>

By definition, drainage alteration and stream control fundamentally changes the course or location of flood waters so the local effect is very high. The effect of proposed diversions and such like will be confined to the mineable areas.

B. <u>a (4/2) - Urbanization</u>

The hard surfacing and ditching connected with urbanization, etc,. lessens infiltration and concentrates run-off water. This effect is local in nature.

C. <u>b (7/2) - Surface Excavation</u>

See comments under C (b) for 2.a - Surface Water.

C. <u>f (5/2) - Clearcutting</u>

Clearcutting reduces interception and allows for faster run-off but in terms of magnitude and extent the effect would be local.

E. <u>c (5/2) - Strip Mining Rehabilitation</u>

A refinishing of the land surface creates new patterns of drainage and, therefore, affects flood potential. Impact is local.

F. <u>a (3/2) - Reforestation</u>

Same comments apply as in C (f). Effects are reversed.

H. <u>c (3/2) - Emplacement of Tailings</u>

Same comments may apply as in E (c). New land forms are being created.

4.b.c EROSION AND DEPOSITION

Erosion and deposition are influenced by land disturbance which removes protective cover and by changes in the rate of flow of water over the land surface. In addition to remarks made in 2 (a) - A (f) - Surface Water and 4 (a) - A (f) - Floods, consideration must include the fact that a new channel will likely be less likely to erosion than an old one.

B. a (6/1) - Urbanization

Hard surfacing inhibits erosion while ditching usually enhances it considerably - both high impacts but on a point area.

C. b (4/2) - Surface Excavation

Erosion will certainly occur on the uncovered clay areas but this will be of no consequence beyond the excavation.

C. f (7/2) - Clearcutting

Clearcutting with the accompanying surface disturbance caused by heavy machinery generally leads to considerable erosion but again the big effect is local.

E. c (7/3) - Strip Mining Rehabilitation

Rehabilitation and the manner in which it is accomplished will significantly effect the erodibility of the land. Local scale.

F. a (7/3) - Reforestation

See comments under C (f).

H. c (6/2) - Emplacement of Tailings

Tailings, spoil and piles of overburden have a high potential for local erosion effects and in certain cases such as the present GCOS tailings pond in the floodplain of the Athabasca River, the erosion and deposition consequences of a tailings pond failure could be dramatic if, for example, the Athabasca River should receive a sudden huge charge of same.

4.e SORPTION

Each mineral of the clay fraction of a soil has a characteristic sorption or ion exchange capacity. In Alberta, the mineralogy of the clay fraction is quite uniform and consists mainly of montmorillinite. Introduction, therefore, of soils with similar texture will cause little or no change in the sorption. However, introduction of sand will lower the sorption drastically. In general, the environmental impact on sorption is small and very localized, resulting in low values for magnitude and importance.

E. c (3/2) - Strip Mining Rehabilitation

H. c (3/2) - Emplacement of Tailings

4.f COMPACTION AND SETTLING

By definition the heaping up of huge quantities of earth will lead to compaction and settling of the placed material and the material beneath it. Significant actions are as follows:

E. c (8/3) - Strip Mining Rehabilitation

H. c (6/1) - Emplacement of Tailings

4.g STABILITY

A. f (6/1) - Alteration of Drainage

Diversion of streams away from the mining areas will have an intermediate local effect on the natural stability of the watershed and surrounding land environment.

C. a (9/1) - Blasting and Drilling

Blasting and drilling has major local impact in that it is designed to decrease stability of the oil sands strata in the areas to be mined. Sliding and slumping will, therefore, occur at the mine face and may be a safety hazard if a mining face is abandoned.

C. b (5/2) - Surface Excavation

Stability of overburden and oil sands materials is decreased on a local scale due to the method of surface mining.

C. f (4/2) - Clearcutting and Other Lumbering

As the surface vegetation is an important factor in maintaining stability of overburden materials - particularly sandy materials - removal of vegetation has the impact of decreasing slope stability, again on a local basis.

E. a, c, d (8/3) - Strip Mining Rehabilitation

The methods of strip mining rehabilitation to be used are of considerable importance with respect to stability. Adequate landscape design and control of slope angles, etc., will ensure that restored slopes remain reasonably stable. Creation of overly steep slopes in the reclaimed areas will inevitably result in local sliding and slumping with resultant increased erosion and sedimentation into the drainage system.

F. a (4/2) - Reforestation

Re-establishment of a vegetation cover in the mined-out areas has equal importance to the removal of that cover. Ultimate reforestation is considered desirable to ensure stability of the recreated landscape, and to minimize erosion hazard and the potential for slumps and slides.

H. c (6/1) - Emplacement of Tailings, Spoil, and Overburden

The location and design of tailings and waste areas may have considerable importance in terms of increasing the local potential for sliding and slumping. The GCOS tailings pond is an example in kind. Local stability may be decreased due to either the inherent instability of the tailings materials themselves, or due to changes in the water table brought about through the impoundment and subsequent leakage of process waters.

II PROPOSED ACTIONS — ENVIRONMENTAL IMPACT

INSTRUCTIONS

1- Identify all actions (located across the top of the matrix) that are part of the proposed project.
2- Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.
3- Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, the least, (no zeroes). Before each number place + if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e. g. regional vs. local); 10 represents the greatest importance and 1, the least (no zeroes).
4- The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers.

SAMPLE MATRIX

	a	b	c	d	e
a		2/1			8/5
b		7/5	8/8	3/1	9/7

PROPOSED ACTIONS

A. MODIFICATION OF REGIME
a. Exotic flora or fauna introduction * Not Applicable
b. Biological controls *
c. Modification of habitat *
d. Alteration of ground cover
e. Alteration of ground water hydrology
f. Alteration of drainage } (f & g combined)
g. River control and flow modification
h. Canalization *
i. Irrigation *
j. Weather modification *
k. Burning *
l. Surface or paving *
m. Noise and vibration *

B. LAND TRANSFORMATION AND CONSTRUCTION
a. Urbanization
b. Industrial sites and buildings } (a, b, c, d, e, f combined)
c. Airports
d. Highways and bridges
e. Roads and trails
f. Railroads
g. Cables and lifts *
h. Transmission lines, pipelines and corridors (Refer to G-k)
i. Barriers including fencing *
j. Channel dredging and straightening } (Refer to A-f & g)
k. Channel revetments
l. Canals
m. Dams and impoundments
n. Piers, seawalls, marinas, and sea terminals *
o. Offshore structures *
p. Recreational structures *
q. Blasting and drilling *
r. Cut and fill (Refer to A-f & g)
s. Tunnels and underground structures *

C. RESOURCE EXTRACTION
a. Blasting and drilling
b. Surface excavation
c. Subsurface excavation and retorting *
d. Well drilling and fluid removal *
e. Dredging *
f. Clear cutting and other lumbering
g. Commercial fishing and hunting *

D. PROCESSING
a. Farming *
b. Ranching and grazing *
c. Feed lots *
d. Dairying *
e. Energy generation
f. Mineral processing
g. Metallurgical industry *
h. Chemical industry *
i. Textile industry *
j. Automobile and aircraft *
k. Oil refining
l. Food *
m. Lumbering *
n. Pulp and paper *
o. Product storage
(e, f, k, o combined)

E. LAND ALTERATION
a. Erosion control and terracing
b. Mine sealing and waste control *
c. Strip mining rehabilitation } (a, c, e combined)
d. Landscaping
e. Harbor dredging *
f. Marsh fill and drainage (Refer to A-e)

F. RESOURCE RENEWAL
a. Reforestation
b. Wildlife stocking and management *
c. Ground water recharge *
d. Fertilization application *
e. Waste recycling *

G. CHANGES IN TRAFFIC
a. Railway *
b. Automobile *
c. Trucking *
d. Shipping *
e. Aircraft *
f. River and canal traffic *
g. Pleasure boating *
h. Trails *
i. Cables and lifts *
j. Communication *
k. Pipeline

H. WASTE EMPLACEMENT AND TREATMENT
a. Ocean dumping *
b. Landfill
c. Emplacement of tailings, spoil and overburden
d. Underground storage *
e. Junk disposal
f. Oil well flooding *
g. Deep well emplacement *
h. Cooling water discharge
i. Municipal waste discharge including spray irrigation *
j. Liquid effluent discharge (cooling water) (j, k, n combined)
k. Stabilization and oxidation ponds
l. Septic tanks, commercial and domestic (municipal waste discharge)
m. Stack and exhaust emission
n. Spent lubricants

I. CHEMICAL TREATMENT
a. Fertilization *
b. Chemical deicing of highways, etc. *
c. Chemical stabilization of soil *
d. Weed control *
e. Insect control (pesticides) *

J. ACCIDENTS
a. Explosions
b. Spills and leaks
c. Operational failure

OTHERS
a.
b.

COMPUTATIONS

A. PHYSICAL AND CHEMICAL CHARACTERISTICS (EXISTING CHARACTERISTICS OF THE ENVIRONMENT)

1. EARTH
a. Mineral resources
b. Construction material
c. Soils
d. Land form
e. ~~Force fields and background radiation~~
f. Unique physical features

2. WATER
a. Surface (Quantity - Conservation Aspects)
b. ~~Ocean~~
c. Underground
d. Quality
e. Temperature
f. Recharge
g. Snow, ice, and permafrost

3. ATMOSPHERE
a. Quality (gases, particulates)
b. Climate (micro, macro)
c. Temperature

4. PROCESSES
a. Floods
b. Erosion
c. Deposition (sedimentation, precipitation)
d. Solution
e. Sorption (ion exchange, complexing)
f. Compaction and settling
g. Stability (slides, slumps)
h. ~~Stress-strain (earthquake)~~
i. Air movements