GREAT CANADIAN OIL SANDS DYKE DISCHARGE WATER

SUMMARY REPORT OF THE SCIENTIFIC ENQUIRY COMMITTEE

August 13, 1976

Alberta
ENVIRONMENT

Edmonton
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The Honourable D.J. Russell
Minister of the Environment
Government of Alberta
222 Legislative Building
Edmonton, Alberta
T5K 2B6

Dear Mr. Russell

SUMMARY REPORT OF THE SCIENTIFIC ENQUIRY COMMITTEE
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The undersigned are pleased to present herewith the summary report of the Scientific Enquiry Committee. This report represents a consensus of the members of the Committee.

The individual reports prepared by the members of the Committee will be forwarded under separate cover *verbatim*. It is recommended that these reports be made available for inspection through the Department of Environment Library.

Respectfully submitted

J.M. Atkinson, P. Eng.

P.H. Bouthillier, P. Eng.

Dr. D.N. Gallup

Dr. S. Greenhill, M.D.

Dr. W.C. Mackay

Dr. N.R. Morgenstern, P. Eng.

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INTRODUCTION

Enquiry Committee

The Scientific Enquiry Committee was appointed by the Hon. D.J. Russell, Minister of the Environment, to investigate factors associated with the discharge of effluents from the Great Canadian Oil Sands (GCOS) tailings pond dyke to the Athabasca River.

The Enquiry Committee was made up of the following members:

J.M. Atkinson, P. Eng.
Consulting Engineer
Reid, Crowther and Partners Limited

P.H. Bouthillier, Professor
Department of Civil Engineering
University of Alberta

Dr. D.N. Gallup, Assistant Professor
Department of Zoology
University of Alberta

Dr. S. Greenhill, M.D.
Chairman, Department of Community Medicine
Faculty of Medicine
University of Alberta

Dr. W.C. Mackay, Associate Professor
Department of Zoology
University of Alberta

Dr. N.R. Morgenstern, Professor
Department of Civil Engineering
University of Alberta

Terms of Reference

The terms of reference of the Enquiry were to evaluate the impact of the discharges on the Athabasca River, and to provide recommendations on any necessary action to be taken by Alberta Environment and Great Canadian Oil Sands Limited. The general nature of the terms of reference has permitted an independent and unrestricted enquiry.

Committee Operation

During the course of the enquiry the Committee has met on four occassions. The first meeting was held on June 17, 1976, and the individual responsibilities of the members were established. These responsibilities were further defined during subsequent discussions. The final assignment of responsibilities was as follows:

Dr. N.R. Morgenstern	-	Engineering and hydrologic aspects of the dyke drainage system.
P.H. Bouthillier	-	Environmental engineering aspects and the mixing characteristics of the Athabasca River.
Dr. W.C. Mackay	-	Biological toxicity of the dyke discharges.
Dr. D.N. Gallup	-	Impact assessment of the dyke discharges on the Athabasca River.
Dr. S. Greenhill	-	Public health and medical aspects of the discharges.
J.M. Atkinson	-	Review of individual submissions and preparation of the draft summary report.

The second meeting was held on June 25, 1976, at the GCOS plant site. This allowed an investigation of field conditions to be undertaken. During this field visit discussions were held with Dr. R. Wallis, the Chairman of the Alberta Oil Sands Environmental Research Program Aquatic Fauna Committee, on the availability of data pertinent to the enquiry.

A third meeting was held on July 27, 1976. At that meeting the individual reports were reviewed and a concensus was obtained on the outline of the summary report. At the final meeting on August 11, 1976, the final report was approved.

Data Sources

The Enquiry has been carried out by review of the following documents that were made available to the Committee Members.

1. Alberta Environment License to Operate or Use 73-WL-041.
2. Alberta Environment License to Operate or Use 73-WL-041A.
3. Alberta Environment Correspondence Files.
4. Alberta Environment Water Quality Records.
5. Water Survey of Canada - Athabasca River flow data.
6. GCOS Report to Alberta Environment dated April 8, 1974.
7. GCOS Bioassay data.
8. Hrudey, S.E. 1975. Characterization of waste waters from the Great Canadian Oil Sands bitumen extraction and upgrading plant. Water Pollution Control Section, Environmental Protection Service, Northwest Region, Environment Canada. Report No. E.P.S. 5-NW-WP-75-6.
9. Strosher, M.T. and E. Peake. 1976. Evaluation of oilsand extraction plant tailings pond waste water. Environmental Sciences Centre, University of Calgary, Alberta, Canada (Draft Copy) (Submitted to Environmental Protection Service--Contract No. 5502-KE204-5-EP32).

HISTORICAL PERSPECTIVE

The Tailings Facility

The Tar Island tailings dyke was originally designed for the retention of tailings produced by GCOS using the hot water bitumen extraction process. The dyke and retention pond, located adjacent to the Athabasca River, were

intended to contain all tailings until sufficient space became available in the mined out area for tailings storage. It is anticipated that the mined out area will be used for tailings disposal by 1977 or 1978.

The initial intent was to construct a conventional earth-fill dyke to a height of 40 feet (crest elevation 820) and construction began in 1965. In 1966 modifications to the earth-fill dyke were considered because GCOS found that more storage for tailings was required. Hence studies began to investigate methods of increasing the height of the dyke using tailings as a construction material.

In November 1967 a design was approved by the Energy Resources Conservation Board which utilized tailings sand placed by the hydraulic fill method and subsequently densified. This construction procedure generates effluent from the dyke during construction which is absent in rolled earth fill placement and also results in a more porous structure requiring careful seepage control through a drainage system, to ensure stability. This practise has been followed here and a large portion of the seepage passing through the dyke is collected by the drains.

A comprehensive monitoring program on the rate of seepage has been undertaken by GCOS and their consultants. A large number of piezometers have been installed to observe the water pressure distribution in the dyke and the discharge from each drain is monitored on a systematic basis. Details of measurements are available from GCOS.

In November 1974 approximately 425,000 gallons/day were being collected by the drains. About 85% was discharged from the filter at elevation 823 and about 11% from the toe drains. Theoretical calculations suggest that the drains were collecting some 55-70% of the total flow through the dyke and foundations. The rest either flows through the foundation unnoticed or emerges as seepage from the face. Some of the latter discharge finds its way down the bank but much of it evaporates in summer. Discharge through the foundations is much influenced by the local composition which varies from clay (impervious) to sand.

Great Canadian Oil Sands intends to raise the dyke elevation to 1070. The ultimate behaviour of the pond is not known at this time so that it is prudent to assume that reusable water will pond above the sludge and if not drawn away, will augment seepage through the dyke. Theoretical estimates suggest that raising the pond level will increase the flow through and below the dyke significantly. A factor of 2-3 times the flow in November 1974, is possible. The flow collected by the filters cannot be estimated with ease but a significant increase should be anticipated. Hence raising the elevation of the pond as presently intended will lead to a significant increase in seepage of effluent from the dyke. The duration of this behaviour is now known at this time since GCOS has not filed their proposals for abandonment. The long-term seepage characteristics depend upon provisions for withdrawal of reusable water from the pond. Unless reusable water is drawn off, seepage will continue for a very long time.

License Requirements

Thw GCOS tailings pond is covered under the Alberta Environment License 73-WL-041 issued on May 31, 1973 Clause 3-2(e) of the license refers to the tailings operation as follows:

The Company shall:

(i) review the nature of seepage entering the Athabasca River from the tailings pond;

(ii) review the potential for occurrences of seepage from that area of the mining pit which shall be utilized for tailings disposal; and

(iii) submit a report relating to the matters specified in sub-sections (i) and (ii) to the Director of Standards and Approvals by April 1, 1974.

Pertinent Correspondence

The correspondence relating to the dyke discharges has been reviewed and most pertinent items are summarized herein:

1. The concern with dyke discharges was stated in a letter dated

September 21, 1973, from Alberta Environment to the E.R.C.B. This letter requested that seepage monitoring include:

(a) Seepage rates

(b) Expected seepage rates at higher elevations

(c) Quality of effluent

(d) Quality of impounded water

(e) Details of the monitoring program

2. The GCOS report on seepage was submitted in April 8, 1974. The report provided a detailed assessment of the drainage requirements, however, only limited data were provided on seepage quality characteristics. The testing program was restricted to analysis for, pH, phenols, oil, and suspended solids.

3. The minutes of a meeting held on December 3, 1975 between GCOS and Alberta Environment document the concern over the potential toxic nature of the seepage. As a result of this meeting, GCOS provided the following comments in a letter dated December 5, 1975.

   1. *A large sum of money has been earmarked in our 1976, 1977 and 1978 budgets to cover a solution to the problem.*

   2. *Our Technical Engineering Section and our Central Engineering Section both have active projects in hand on this problem. The Technical Section is to determine the final disposal of this water and the Central Engineering Section is to determine how to collect and handle the water.*

DYKE DISCHARGE CHARACTERISTICS

Data Sources

Available information on water quality characteristics of the dyke discharges is very limited. The data sources for this enquiry are as follows:

(a) GCOS	Analysis of pH, oil, phenol and suspended solids during the period 1970 to 1974.

(b) Alberta Environment	Comprehensive analysis on three sampes collected on separate dates in November 1973 and five samples collected on June 23, 1976.
(c) Environment Canada	One static bio-assay using a grab sample collected on August 14, 1974. One grab sample for physical - chemical analysis collected on the same date. A grab sample collected on September 18, 1974 for trace organic analysis.

The data limitations are recognized especially in regard to the number of sampling events and the statistical validity of the analysis is therefore limited.

Physical - Chemical Data

Heavy metal concentrations are within accepted Alberta surface water quality criteria (s.w.q.c.) for all samples, with the exception of the Alberta Environment sample 9912 of November 7, 1973. Results for heavy metal concentrations on that date are as follows:

	Sample 9912 mg/l	s.w.q.c. mg/l
Copper	0.19	.02
Chromium	1.5	.05
Zinc	1.75	.05
Cadmium	0.05	.01
Lead	0.91	.05

The above concentration in undiluted effluent could be toxic to aquatic life especially in consideration of the Cu/Zn/Cd synergism. It is also noted that the ammonia concentration of 27 mg/l in undiluted effluent (sample 9912) would be lethal to rainbow trout at normal temperatures and pH of the discharge.

The other important observation that can be made from examination of the data is the high concentration of organics. Chemical oxygen demand values are high in each sample, ranging from 307 mg/l to 2200 mg/l.

Bio-Assay Data

The single static bio-assay carried out by Environment Canada (Hrudey, 1975) on the dyke discharge effluent indicated that the effluent exhibited high parameter concentrations, notably organic carbon, and was acutely toxic to rainbow trout. The toxicants were five times more concentrated than that required to kill 50 percent of the test population in 96 hours.

In addition to the Environment Canada test, static bio-assays have been carried out by GCOS on Athabasca River water. Samples were taken from the river at the boat dock, located downstream of the dyke discharges and upstream of the process waste water pond discharge. Thirteen samples were collected and tested in the period February 1974 to February 1975. All samples tested indicated 100 percent survival of rainbow trout after 96 hours.

EFFLUENT MIXING CONSIDERATIONS

The dilution of the seepage effluent in the Athabasca River is most pertinent to this enquiry, in order that the impact of the discharge may be assessed.

Diffusion studies have been carried out on the Athabasca River downstream from GCOS by Alberta Research Council. Mr. Beltaos of A.R.C. has made the following estimate of dilutions of the seepage effluent for this enquiry.

River Miles Downstream of GCOS	Dilution (Left Bank) Winter	Summer
2	1:1000	1:2000
5	1:1600	1:3300
10	1:2300	1:4800
15	1:2800	1:5400
Ultimate	1:8100	1:27000

IMPACT ASSESSMENT

Biological Considerations

It is clear from the Environment Canada data that the sample of dyke discharge effluent tested was acutely toxic to rainbow trout. The exact cause of the toxicity is not known, but it was likely a combination of trace organics, ammonia, and heavy metals.

However, in assessing the acute toxicity impacts on the Athabasca River the following factors should be considered:

(a) GCOS static bio-assays on 13 samples of river water collected downstream of the dyke discharges indicated 100 percent survival of rainbow trout.

(b) Native fish species may be less sensitive than the test species.

(c) In other river systems the background hardness, calcium, temperature, and turbidity have been found to reduce heavy metal toxicity. This situation may well apply to the Athabasca River system.

(d) The dilution of the seepage effluent in the River is high.

In order to draw firm conclusions on acute toxicity effects it would be necessary to have data such as invertebrate species abundance and biomass and native fish caging tests, upstream and downstream of the discharges. However, on the basis of the available information and considerations, it is reasonable to conclude that acute toxic effects on the Athabasca River if any, will be minimal and restricted to a local area at the points of discharge.

Although acute toxicity is not considered an impact, there is considerable concern over the potential chronic effects of the seepage discharges. It is not possible to draw any conclusions concerning this factor due to the lack of available data and a detailed investigation is considered necessary and warranted to define this potential concern. Such an investigation would require considerable time and would involve the investigation of the uptake of potential toxicants in the tissue of vertebrates and invertebrates.

Possible Health Impacts

Examination of chemical analyses reveals levels of cadmium, chromium and lead in one sample (9912) of undiluted seepage effluent which are several times larger than mandatory upper limits for drinking water, according to accepted potable water criteria. However, when dilution of the dyke discharge effluent is considered, the concentrations in Athabasca River water are more than an order of magnitude below the mandatory upper limits for drinking water.

The residents of Fort MacKay, about fifteen miles downstream of GCOS, use the Athabasca River in part as a water supply source. Other sources used are wells and the MacKay River. The dilution at this point in the Athabasca River is high. However, the long term impacts cannot be assessed from the available data at this time.

POSSIBLE MITIGATION MEASURES

There are two basic engineering solutions for treatment of the seepage dischage:

1. Collection of the wastes and treatment to remove toxic components prior to discharge.

2. Collection and recycle of the wastes.

The first alternative is not considered practical in terms of economics or available technology. The second alternative is possible although there are significant engineering problems to be resolved.

The GCOS letter of December 5, 1975 indicates that funds have been budgeted and design initiated for the second alternative. These aspects should be refined and specific designs and cost estimates submitted.

SUMMARY AND CONCLUSIONS

1. The tailings pond dyke at the Great Canadian Oil Sands operation, by virtue of its nature and use, is a structure from which significant volumes of seepage flow. As long as the hydraulic method of stacking tailings is employed and the upper reusable 15 feet of water stands in the pond, water will continue to percolate through the dyke.

2. The company is operating within the terms of the licence issued by Alberta Environment.

3. It is technically feasible to collect seepage effluent from the numerous drains and to recycle this effluent.

4. Biological toxicity of the undiluted effluent is acute using rainbow trout as test animals. There is no evidence for acute toxic effects on the biota of the Athabasca River or on people using the water. Moreover, no acute effects are anticipated.

5. The chemical composition of the dyke discharge water is complex and variable. The long term implication of its use for humans and other forms of life are not known at this time and therefore is of concern.

RECOMMENDATIONS

1. Drain discharge water from the dyke and ponded surface water on the dyke should be collected and recycled.

2. Detailed studies to assess the long term impact of the discharges on aquatic life and humans should be initiated as soon as possible.

3. When operations similar to that at the GCOS site are contemplated, particularly where large tailings ponds are involved, the impact of seepage should be evaluated and permissive criteria established before the operation begins.

4. Biological impacts should receive stronger emphasis in future planning by Alberta Department of Environment.