Alberta Oil Sands Environmental Research Program Annual Report 1981-1982

AOSERP Report 127

Alberta
ENVIRONMENT
Research Management Division

The logo represents the interdisciplinary and holistic nature of the Division's environmental research programs. Each of the five sections of the symbol represent comprehensive programs on air, water, land, humans, and their constant interaction. The sections converge to form a cohesive chain, characteristic of an effective research organization. This cohesive bonding makes the sections blossom into the environment in the form of a flower — an Albertan wild rose.

ALBERTA OIL SANDS
ENVIRONMENTAL
RESEARCH PROGRAM

Alberta Oil Sands Environmental Research Program

ANNUAL REPORT

1981-1982

AOSERP Report 127

Alberta
ENVIRONMENT
Research Management Division
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10405 Jasper Avenue,
Edmonton, Alberta, Canada
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ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

RESEARCH REPORTS

These research reports describe the results of investigations funded by the Alberta Oil Sands Environmental Research Program. This program was designed to direct and co-ordinate research projects concerned with the environmental effects of development of the Athabasca Oil Sands in Alberta.

A list of research reports published to date is included at the end of this report.

Enquiries pertaining to the reports in the series should be directed to:

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Alberta Oil Sands Environmental Research Program
Annual Report 1981/82

AOSERP Report 127

This report may be cited as:

Research Management Division. 1982. Alberta Oil Sands Environmental Research Program Annual Report 1981/82. Prep. by Alberta Oil Sands Environmental Research Program for the Research Management Division. AOSERP Report 127. 43 pp.

The Hon. F. Bradley
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

Sir:

Enclosed is the report "Alberta Oil Sands Environmental Research Program Annual Report 1981/82."

This report was prepared for the Research Management Division, through the Alberta Oil Sands Environmental Research Program.

Respectfully,

W. Sołodzuk, P.Eng.
Deputy Minister, Alberta Environment

This report is made available as a public service. The Department of Environment neither approves nor disagrees with the conclusions expressed herein, which are the responsibility of the authors.

ALBERTA OIL SANDS ENVIRONMENTAL

RESEARCH PROGRAM

ANNUAL REPORT 1981/82

Research Management Division
Alberta Oil Sands Environmental
Research Program

AOSERP Report 127

February 1983

TABLE OF CONTENTS

	Page
DECLARATION	ii
LETTER OF TRANSMITTAL	iii
LIST OF TABLES	viii
LIST OF FIGURES	ix
INTRODUCTION	1
Operational Activities	6
A Note as to the Organization of this Report	6
AIR SYSTEM	9
Air System Activities	11
Projects	13
Publications	16
HUMAN SYSTEM	19
Human System Activities	21
Projects	22
Publications	24
TERRESTRIAL SYSTEM	27
Terrestrial System Activities	29
Projects	30
Publications	32
WATER SYSTEM	35
Water System Activities	37
Projects	38
Publications	42

LIST OF TABLES

Page

1. Total Funds Committed to AOSERP, 1979 to 1982 7

LIST OF FIGURES

Page

1. Map of the AOSERP Study Area 4

2. Research Management Division Organizational Chart 5

INTRODUCTION

INTRODUCTION

The Alberta Oil Sands Environmental Research Program (AOSERP) was created in 1975 as an independent program managed jointly by the Alberta and Federal Governments to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta (Figure 1). Following the unilateral withdrawal by the Government of Canada from the program on 31 March 1979, the responsibility for AOSERP activities was assumed by the Alberta Department of the Environment. At that time, the Research Management Division (RMD) was created within Alberta Environment by the amalgamation of the Research Secretariat and AOSERP.

Among its responsibilities, the Research Management Division provides research support services to the department by initiating, priorizing, funding, and managing scientific research programs and projects concerning the environment. AOSERP undertakes these activities specific to the Athabasca Oil Sands study area.

This report covers AOSERP-sponsored work pertaining to the 1981/82 fiscal year. The last detailed summary of the work activities of the AOSERP Program was contained in the "Alberta Oil Sands Environmental Research Program, 1975-1980: Summary Report," published in 1981. The summary report provides a comprehensive description of the work activities of AOSERP during its first five years.

At the beginning of the 1981/82 year, the Research Management Division had been organized into four systems (Figure 2): 1) Air, 2) Human, 3) Terrestrial, and 4) Water. Correspondingly, RMD staff was organized into four teams, with research into environmental problems being directed to the most relevant of the systems. Support for their activities was provided by other staff working in Operations and Information.

During the last month of the fiscal year, however, the Research Management Division was restructured to develop an integrated interdisciplinary basis for research programs pertaining to both short- and long-term environmental problems and priorities. To this end, the

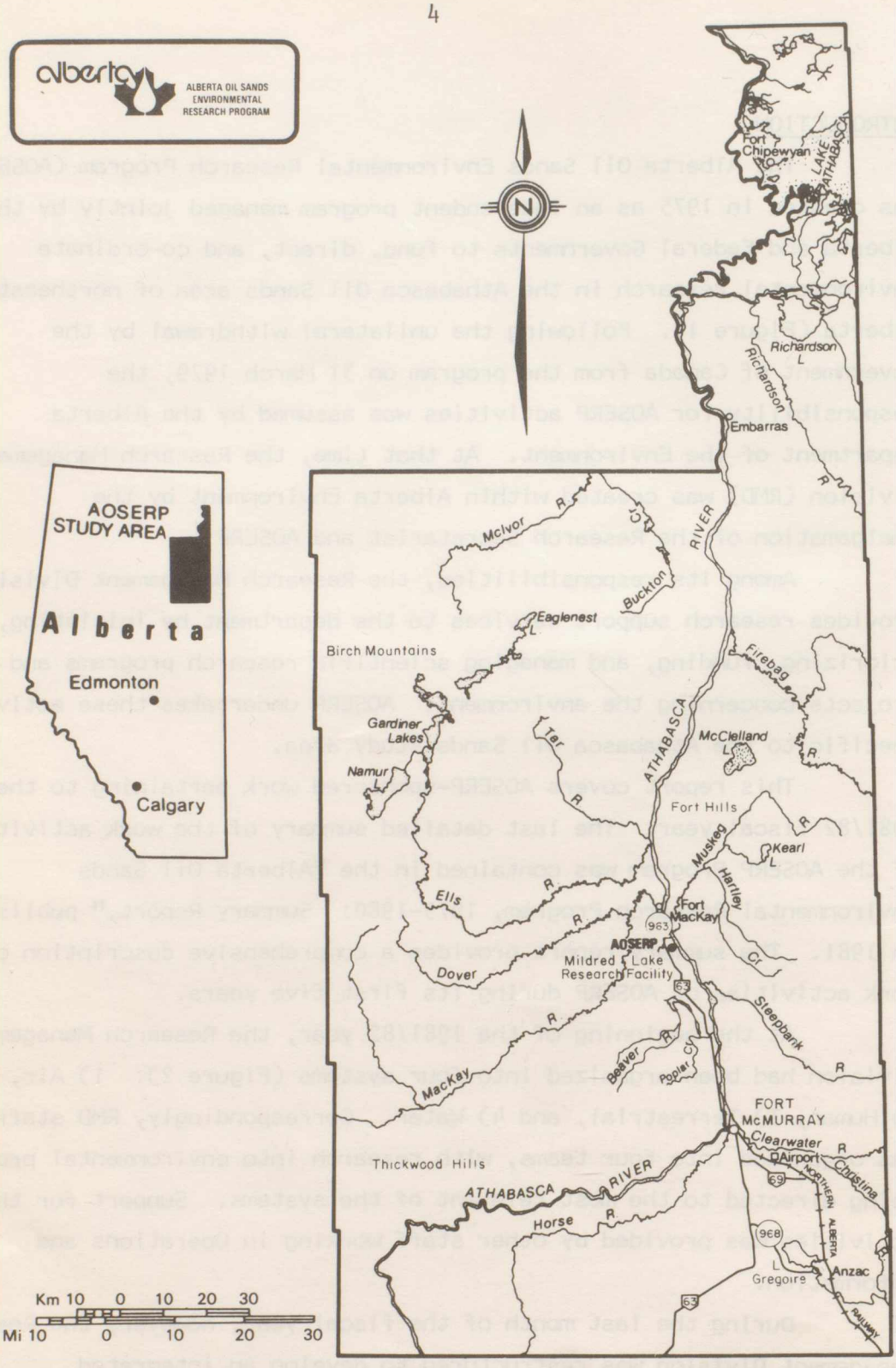


Figure 1. Map of the AOSERP study area.

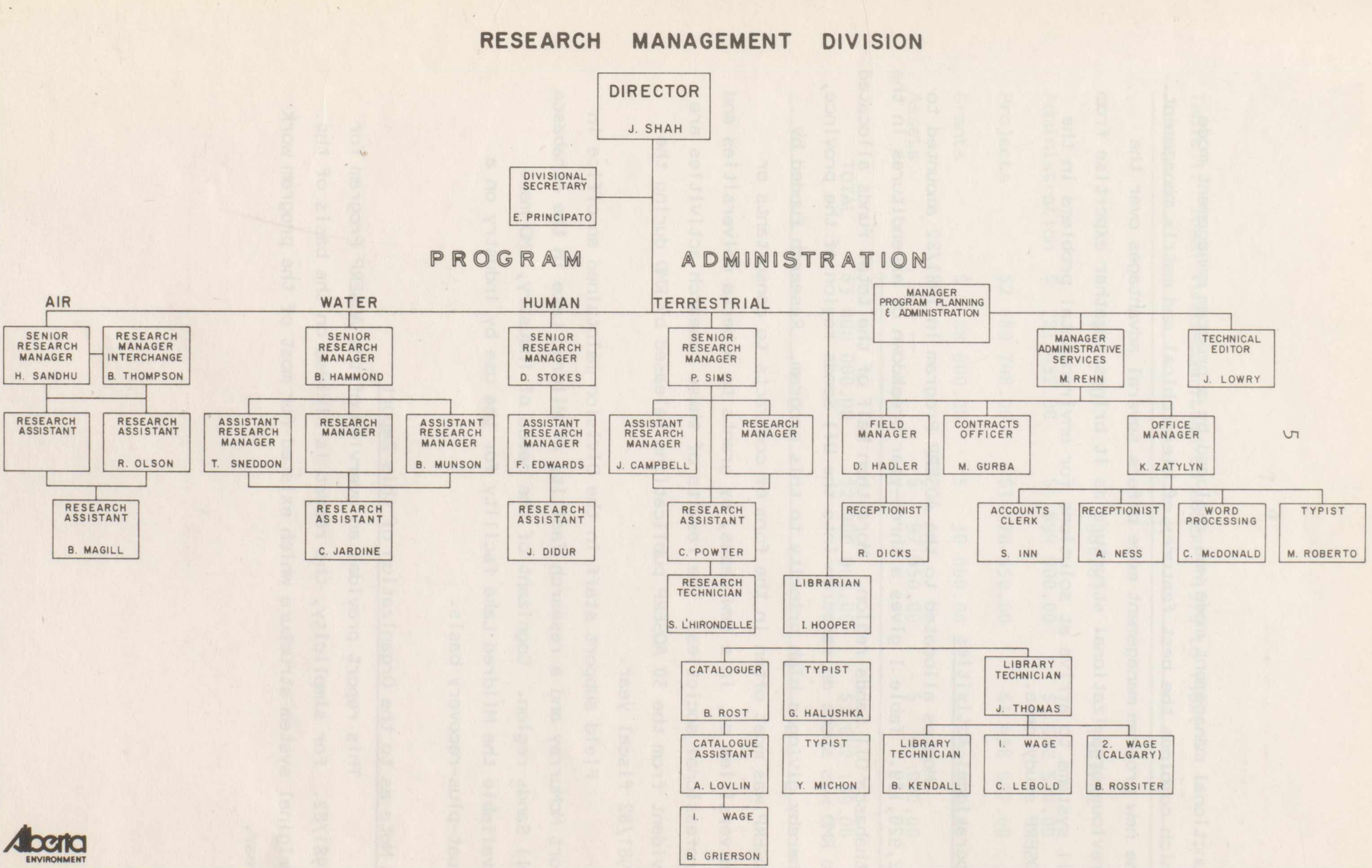


Figure 2. Research Management Division organizational chart.

functional management mode was replaced by a program management mode which combines the best features of hierarchical and matrix management. The new program management mode offers several advantages over the previous organizational structure as it brings together expertise from all systems to arrive at solutions for environmental problems in the AOSERP study area.

Operational Activities

Monies allocated to the AOSERP Program in 1981/82 amounted to $2,920,139. Table 1 gives a three-year breakdown of expenditures in the Athabasca Oil Sands region. More than half of the total funds allocated to RMD was spent on research into the Oil Sands region of the province, thereby giving a high priority to this program. Research funded by AOSERP was most often in the form of contracts to consultants or universities or, in a few cases, by grants to Alberta universities and professional societies. The results of these research activities are evident from the 30 AOSERP publications released by RMD during the 1981/82 fiscal year.

Field support staff in the Division maintained an office in Fort McMurray and a research facility at Mildred Lake in the Athabasca Oil Sands region. Cognizant of the needs of industry, RMD made available the Mildred Lake facility for the use by industry on a cost-plus-recovery basis.

A Note as to the Organization of this Report

This report provides an overview of the AOSERP Program for 1981/82. For simplicity, the report is divided on the basis of the original system structure which existed for most of the program work year.

Table 1. Total funds committed to AOSERP, 1979 to 1982.

	1979/80	1980/81	1981/82
Administration	$ 721 452.00	$ 694 000.00	$ 582 532.00
Projects	$2 189 748.00	$1 170 550.00	$1 438 607.00
Grants	$ 88 800.00	$ 38 000.00	$ 30 000.00
Assets	--	$ 97 450.00	$ 41 000.00
TOTAL	$3 000 000.00	$2 000 000.00	$2 092 139.00

AIR SYSTEM

AIR SYSTEM ACTIVITIES

Transboundary air pollution, especially acid rain and long range transport of air pollutants, has attracted a great deal of attention locally, nationally, and internationally. Air System managers represented the department on numerous provincial, federal/provincial and international committees dealing with this issue. An Air System manager was named as the co-ordinator and spokesman for departmental activities on acid rain and Long-Range Transport of Atmospheric Pollutants (LRTAP). The first annual report on monitoring and research studies related to acid rain and LRTAP in Western Canada was published.

During the fiscal year, a slight change in research direction was implemented for the AOSERP area (Athabasca Oil Sands). While the acquisition of baseline data decreased, new technology in remote sensing of the atmosphere was exploited.

The capabilities of acoustic doppler radar to remotely sense atmospheric parameters has encouraged the Air System to develop research projects in this area. Initial project planning and the acquisition of an acoustic sounder has been completed. To further research in this area, a co-operative project has been undertaken with industry to assess the accuracy and reliability of acoustic sounder data as compared with conventional technology.

The transport and removal mechanisms of anthropogenic pollutants by atmospheric processes continues to be an active research area. The fifth summer event precipitation chemistry project was completed with the co-operation of Alberta Environmental Centre and Alberta Forest Service. The major ions present in the precipitation were determined along with the heavy metals. This analysis has provided further documentation of deposition patterns over the Athabasca Oil Sands area. The depth of the snowpack was also surveyed again to supply a continuing record for climatological studies and to support the ongoing studies of the hydrology of this region.

The emphasis on model development shifted toward the applications research area. A user-oriented frequency distribution

dispersion model was finalized and its applications to air quality studies were reviewed. Windflow patterns in the oil sands area were studied through the application of a mesoscale small area wind model. Through the development and use of these models, information gaps were identified, leading to a joint government/industry project to assess meteorological data acquisition systems to replace the present network.

The Air System has worked closely with the Terrestrial System of RMD to co-ordinate meteorological and air quality information required for an ecosystem monitoring project. Output from a dispersion model was synthesized to assist in sample plot locations. Co-ordination of air quality instrumentation for the project was also undertaken by Air System personnel.

PROJECTS

Air Quality Data Acquisition in the AOSERP Area

At ten monitoring sites in the Oil Sands production area and one in the town of Fort McMurray, measurements were made for sulphur dioxide, carbon monoxide, hydrogen sulphide, nitrogen oxide, and particulate matter. These values were monitored in conjunction with nine meteorological stations. Data summaries are available from RMD.
Funding: $140 000.00 (Jointly funded by the Research Management Division and Pollution Control Division)

Airshed Management Modelling Systems for the AOSERP Area Phase III

This project was undertaken to develop a model capable of providing a versatile, user-oriented display of a frequency distribution and average ground level concentration of pollutants. It will provide information to managers relating the pollution in the AOSERP Area to future industrial development needs.
Funding: $11 000.00

AMOCO Gregoire Lake Monitoring Program

Ground level concentrations of sulphur dioxide, carbon monoxide, nitrogen oxides, and particulates were measured in the vicinity of the in situ pilot plant near Stoney Mountain. Surface meteorological parameters were also measured.
Funding: $27 500.00

Computer Modelling of Low-Level Winds and Temperatures over the Southeastern AOSERP Study Area

A low-level planetary boundary layer model has been adapted to the central AOSERP study area to provide data on low-level winds and temperatures. It incorporates the effects of topography and thermal circulations on low-level wind flow. The model formulation requires less detailed meteorological initialization than a previous version, yet

maintains the same physical processes. This change will allow the model to be more easily adapted to other areas of Alberta where detailed input data are not available.

Funding: $9 460.00

Event Rain Sampling in the Oil Sands Area

The objective of this project was to sample rain events at 15 locations in the oil sands area. Chemical analyses for sulphate, nitrate, chloride, ammonium, potassium, calcium, sodium, magnesium, and pH provided data for evaluation of deposition rates.

Funding: $35 000.00

Modernization of AOSERP MAPS Automatic Reporting Network

Investigations are being conducted to evaluate the design and cost for modernizing the AOSERP MAPS Automatic Reporting Network. The alternatives are either to repair and upgrade the existing components; to procure and implement a new, state-of-the-art system; or to effect a combination of these two. It appears that a decision will soon be reached.

Funding: $ 7 000.00 (Jointly funded by the Research Management Division and Syncrude Canada Ltd.)

Oil Sands Extraction, Upgrading, and Emission Technology Review

The attainable performance of abatement technologies with respect to gaseous emissions and the recovery of sulphur is limited by the technology available at the time of application or final design. To update the 1976 report "Evolution of Pollution Abatement Technology as Applied to the Alberta Oil Sands," a study was initiated which reviews recent literature sources and contacts process licensors and vendors for the most current technological developments.

Funding: $90 000.00

Snowpack Chemistry in the Oil Sands Area: Final Report

The objective of this study was to determine the pattern and rate of winter deposition of pollutants. Snow samples were analysed

for chemical constituents and results were compared with a 1976 survey.

Funding: $9 048.00

TAGA Ambient Air Monitoring Survey

The objectives of this study were to sample and analyse ambient air in the vicinity of selected industrial sites in Alberta. The chemical composition of these ambient air samples was used to identify and track selected pollutants. The chemical analyses were conducted by employing a TAGA 3000 Mobile Laboratory.

Funding: $50 000.00 (Jointly funded by the Pollution Control Division and Research Management Division)

PUBLICATIONS

Bottenheim, J.N. and O.P. Strausz. 1981. Development of a chemically reactive plume model for application in the AOSERP study area. Prep. for the Alberta Environment, Alberta Oil Sands Environmental Research Program by the Department of Chemistry, University of Alberta. AOSERP Report 117. 159 pp.

Danard, M. and M. Gray. 1981. Computer programmer's supplement to "Modelling topographic effects on winds in the Alberta Oil Sands area." Prep. for Alberta Environment, Research Management Division by Atmospheric Dynamics Corporation. RMD Report OF-33. 19 pp.

Danard, M. and M. Gray. In prep. Modelling topographic effects on winds in the Alberta Oil Sands area. Prep. for Alberta Environment, Research Management Division and Pollution Control Division. September 1981. 82 pp.

Davison, D.S., M.C. Hansen, R.C. Rudolph, and M.J.E. Davies. 1981. Airshed management system for the Alberta Oil Sands. Vol. II: meteorological data. Prep. for Alberta Environment, Research Management Division by Intera Environmental Consultants Ltd. and Western Research and Development. AOSERP Report 120. 89 pp.

Murray, W.A. 1981. Gregoire Lake monitoring program: six month report, April to September 1979. Prep. for AMOCO Canada Petroleum Company Ltd. and Alberta Environment, Research Management Division. RMD Report L-69. 66 pp.

Murray, W.A. 1981. The snowpack survey in the AOSERP study area. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Promet Environmental Group Ltd. AOSERP Report 125. 137 pp.

Peters, R.R., H.S. Sandhu, and W.D. Hume. 1981. An analysis of precipitation chemistry in the oil sands area of northern Alberta. Proceedings of Air Pollution Sessions. Canada Meteorological and Oceanographic Society, 15th Annual Congress; 1981 May 27-29; Saskatoon, Saskatchewan. 10 pp.

Strosher, M.M. 1981. Background air quality in the AOSERP study area, March 1977 to March 1980. Prep. for Alberta Environment, Research Management Division by Pollution Control Division. AOSERP Report L-73. 84 pp.

Technical Committee for the Long-Range Transport of Atmospheric Pollutants in Western Canada. Western Canada LRTAP Activities: Annual report 1981; a report on monitoring and research studies related to acid rain and long-range transport of atmospheric pollutants in Western Canada. Edmonton: Technical Committee for the Long-Range Transport of Atmospheric Pollutants in Western Canada. 1981.

HUMAN SYSTEM

HUMAN SYSTEM ACTIVITIES

Human System research in the oil sands area has functioned at a reduced level over the last year. Work consisted of synthesizing already-gathered data. Because the research direction has been modified, information must be collected in such a way that it is of value to the agencies who use this information. Therefore, translation of data into a policy and into usable information was piloted last year and will become an integral part of every human system research project. Data from Fort McMurray has been re-analysed and re-interpreted to help policy formulation by the New Town Planning Board in Northern Alberta. The Human System also worked closely with the Air System and the Environmental Health Division of the Department of Social Services and Community Health to assess the feasibility of looking at the environmental health status of people living in Fort MacKay. This project was eventually taken over by the Federal Government.

PROJECTS

An Integration and Synthesis of AOSERP Human System Research Results

Since 1975, data have been collected under the auspices of AOSERP to determine the changes that have taken place in the oil sands area due to the development of the area's resources. This project will provide a synthesis of the data collected to date.

Funding: $15 538.00

Human Side of Energy

A forum on the Human Side of Energy was held in August 1981 at the University of Alberta. It attracted 375 people from the US and Canada who discussed how issues of energy development affect human populations. Included were such topics as: planning for energy development; impact of megaprojects on Albertans; and the future of native participation in Canadian resource development.

An issue of the Department's magazine--Environment Views--was based on this forum. A set of abstracts from the papers presented at the forum is available through the Faculty of Extension, University of Alberta.

Funding: $20 030.00 (Jointly funded by Alberta Environment, Earth Sciences Division and Research Management Division)

Policy Analysis of Fort McMurray Data

Data collected in a 1979 study of family adjustment in Fort McMurray were re-analysed and re-interpreted in the light of planning and policy options for the proposed new town in northeast Alberta. This information came from the New Town Planning Board and the re-interpreted information can be used for future planning.

Funding: $16 500.00

Research Management Framework

An orderly, rationalized way of conducting research was commissioned by the Human System. This included close interaction with the management consultant to ensure that the framework matched the changing needs of the system. A five-page digest is being written and will be available shortly.

Funding: $10 900.00 (Jointly funded by Alberta Oil Sands Environmental Research Program and the Research Management Division)

PUBLICATIONS

Gartrell, J.W., H. Krahn, and F.D. Sunahara. 1980. A study of human adjustment in Fort McMurray. Volume II: technical manual. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Thames Group Research Inc. through the University of Alberta, Population Research Laboratory. RMD Report L-68. 189 pp.

Krahn, H. In prep. New resource towns planning concerns: data report. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program. RMD project 81-27.

Littlejohn, C. and R. Powell. 1981. A study of native integration into the Fort McMurray labour force. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Canadian Institute for Research in the Behavioural and Social Sciences. RMD Report L-70. 168 pp.

Parkinson, A., S.W. Montgomery, and R.D. Humphreys. 1980. A study of the impact of construction camps on the people of northeast Alberta. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Urban Consultants Ltd. and R.D. "Reg" Humphreys Engineering and Management Consultants Ltd. RMD Report OF-23. 121 pp.

Sklofsky, J. In prep. Policy translation. New resource towns planning concerns: policy report. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program. RMD project 81-27.

TERRESTRIAL SYSTEM

TERRESTRIAL SYSTEM ACTIVITIES

During 1981, a concerted effort was made to develop a program of research in support of biological monitoring. Studies funded and managed by the Terrestrial System dealt primarily with developing technology to determine the effects of atmospheric pollutants on terrestrial ecosystems. The objective of this program was to assemble information necessary to determine and evaluate the effects of low levels of pollutants on vegetation and soils processes and to develop an early-warning capability for monitoring systems. Scientific experts were assembled by the Terrestrial System to identify, discuss, and establish priorities for research needs. The next step will be to solicit from industry input to develop the research program. In the meantime, several relevant research projects are being continued.

The Research Management Division has co-operated with the Alberta Oil Sands Technology and Research Authority in a three-year research professorship granted to Dr. E.C. Pielou, a noted ecosystem modeller from Dalhousie University in Halifax, Nova Scotia. Dr. Pielou is now teaching at the University of Lethbridge and has initiated a study on the effects of pollutants on forest vegetation in the oil sands region.

PROJECTS

Alberta Oil Sands Environmental Research Program. 5-Year Report: Review and Revision

This report is a summary of the studies performed from 1975 to 1980 under the auspices of the Alberta Oil Sands Environmental Research Program (AOSERP). The report describes the development and organization of the program, and the individual studies in each system (air, land, water, and human), and provides a discussion of the results obtained from the studies. Recommendations for future research are also provided.

Funding: $22 754.00

Complexity and Stability of Boreal Forest Ecosystems

This project was designed to determine and compare the structural dynamics of several common boreal forest vegetation associations existing along a deposition gradient of pollutants. This study has been initiated in the oil sands area with the establishment and description (soils and vegetation) of sixteen permanent study plots. Two or three state-of-the-art air quality monitoring trailers will be located in close association with these plots. Further studies are being carried out on relatively pollution-free forests in the Hondo/Slave Lake area.

A detailed research program is being developed in co-operation with industry scientists.

Funding: $87 280.00

Effects of Air Pollution on Natural Vegetation

This study will attempt to evaluate the relative effects of natural and anthropogenic factors on forest ecosystems. Morphologic and growth responses (past and present) in jack pine stands throughout the oil sands area will be studied to determine if the effects of pollution can be identified and quantified.

Funding: $102 000.00 (Jointly funded by Alberta Oil Sands Technology and Research Authority and the Research Management Division)

The Impact of Air Pollutant Mixtures on Forest Vegetation and Soils

This study concentrated on laboratory studies to determine the response of soils and vegetation to mixtures of aerial contaminants characteristic of those emitted from oil sands plants.

Funding: $82 000.00 (Jointly funded by Environment Canada, Canadian Forestry Service and the Research Management Division)

Oil Sands Soil Reclamation Project

This is a co-operative project of the Reclamation Research Technical Advisory Committee representing the government of Alberta, and the Oil Sands Environmental Study Group representing industries involved in oil sands development. A literature review was undertaken to determine the soil requirements of reconstructed soils on waste tailings sands. This information is being used in a current study to design reconstructed soils. This study is to test the effect of soil variables on woody plant performance, long- and short-term stability, and survival of the soil/plant system. A project proposal is being developed by an industry scientist and a Research Management Division scientist under the direction of the government-industry steering committee.

This project is managed by RMD, with funding contributed from the Heritage Trust Fund and the Oil Sands Environmental Study Group (OSESG).

PUBLICATIONS

Bliss, L.C., ed. 1979. Performance of vegetation on mined sands. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by the University of Alberta, Department of Botany. RMD Report OF-27. 251 pp.

LaRoi, George H. and Mike Ostafichuk. 1982. Establishment and vegetational survey of 16 Pinus banksiana-dominated permanent plots for the Athabasca oil sands ecological monitoring project in 1981. Prep. for Alberta Environment, Research Management Division by the University of Alberta, Department of Botany. RMD Report OF-34.

Smith, S.B. 1981. Alberta Oil Sands Environmental Research Program, 1975-1980: summary report. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by S.B. Smith Environmental Consultants Limited. AOSERP Report 118. 170 pp.

Turchenek, L.W. 1982. Soils of permanent sample plots in the Athabasca oil sands area. Prep. for Alberta Environment, Research Management Division by Alberta Research Council, Soils Department. RMD Report OF-36. 71 pp.

Turchenek, L.W. and J.D. Lindsay. 1981. Soils inventory of the AOSERP study area. Appendix. Prep. for Alberta Environment, Research Management Division by Alberta Research Council. RMD Report OF-31. 264 pp.

Turchenek, L.W. and J.D. Lindsay. In prep. Soils inventory of the Alberta Oil Sands Environmental Research Program study area: appendix 9.4. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Alberta Research Council, Soils Department. RMD Report L-80.

WATER SYSTEM

WATER SYSTEM ACTIVITIES

Water System research in the oil sands area in the 1981/82 fiscal year involved major efforts in: fundamental research into surface water and groundwater; biological, chemical, and hydrometric monitoring; and investigations into the environmental consequences of in situ bitumen extraction technology. Geographically, studies were divided between the Athabasca and Cold Lake deposits.

Surface and groundwater fundamental research included studies to estimate, describe, and provide a predictive calibrated mathematical model for the distribution and circulation of water and sediment in the Athabasca River and Delta. Hydrologic and sediment regimes were also examined in disturbed and undisturbed sites in the Muskeg River basin. A water atlas project explored the possibility of producing a comprehensive inventory of all waters in Alberta.

Two major ongoing monitoring projects continued in the Athabasca Oil Sands area: water quality monitoring under the direction of the Pollution Control Division; and monitoring of the hydrometric and suspended sediment under the Technical Services Division. These projects continue to provide an uninterrupted set of baseline information for the region. A project to develop biological monitoring techniques for the Athabasca River was conducted concurrently with the water quality component.

In view of current pilot projects on in situ recovery of bitumen from the oil sands, and in anticipation of a potential increase in these activities in the future, several studies were developed to fully explore and evaluate the possible environmental implications of in situ extraction technologies. In co-operation with the Groundwater Branch of the Earth Sciences Division, research continued into induced seismicity related to fluid injection at Cold Lake. A positive seismic monitoring array is fully operational, and the data derived are being reduced and analysed by the University of Alberta. Projects studying the toxicology of products produced from the various in situ methods and the geomechanics of in situ development were conducted in co-operation with Alberta Oil Sands Technology and Research Authority (AOSTRA).

PROJECTS

A Regional Assessment of Hydrogeological and Hydrochemical Conditions in the Cold Lake Oil Sands Deposit

This project will develop a three-dimensional framework of the hydrostratigraphy, hydrodynamics, and hydrochemistry of the Cold Lake Oil Sands area. It will also identify the processes inherent to both in situ recovery and deep waste disposal methods, and evaluate their possible effects on local and regional groundwater regimes of the study area. Where significant effects are noted, recommendations will be made for further study aimed at the quantification of these potential impacts for local and regional scales. Phase I of this project is imminent.

Funding: $235 000.00 (Jointly funded by Alberta Research Council and the Research Management Division)

Biological Monitoring of the Athabasca River

This project was designed to develop biological monitoring techniques for implementation on large river systems.

Funding: $12 100.00

Cold Lake Seismic Array

This project will provide baseline seismicity information in the Cold Lake Oil Sands area. Further objectives are: to identify the source locations of the observed events and to identify or suggest their causes; to describe the environmental significance of observed seismic events and their relationship to current activities; to make recommendations concerning ongoing monitoring after the basic study is completed; and to design mitigative engineering features. Operation of the array and the dissemination of data are being carried out by the Earth Sciences Division.

Funding: $19 395.00

The Delineation of the Minimum Principal Stress Value, Determination of Fracture Orientation, and Mechanical Investigation of Colorado Clay Shales at the Cold Lake Oil Sands Deposit

This project will prepare a proposal and work plan for in situ measurement of the value of the minimum principal stress for at least five depths between the top of the Clearwater formation and the first confined aquifer in the drift in the Cold Lake area under the Beverly Channel.

Funding: None in 1981/82

Distribution and Circulation of Water and Sediment in the Athabasca River and Delta

This project was designed to estimate and describe how water from the Athabasca River is distributed through the delta system under various flow and ice conditions, and at various levels of Lake Athabasca. It will also estimate and describe the circulation and mixing of river water in Lake Athabasca under various conditions, and their relationship to outflows to the Slave River and to cross-connections with Mamawi Lake and Lake Claire. The distribution, circulation, and deposition of sand and fine sediment carried to the mouth of the Athabasca will be described for both the delta and Lake Athabasca. Flow-specific processes will be related to the possible contamination of the Athabasca River delta by upstream sources.

Funding: None in 1981/82

Hydrology and Sediment Yield of the Muskeg River Basin: Northeastern Alberta

This project will describe and explain the hydrologic and sedimentologic regimes of disturbed and undisturbed sites in the Muskeg River basin. It will also develop a predictive capability for the magnitude and frequency of flows, and the volume and size characteristics of material entering the river system from upland erosion as a result of the exposure of the mineral soil after muskeg removal.

Funding: $25 000.00

Hydrometric and Suspended Sediment Network

This is an ongoing project providing adequate streamflow information for an inventory of hydrology resources for the AOSERP study area. The data are to be used in water quantity and quality, water use, flood flow, and modelling studies. This project also provides background information on the temporal distribution of suspended sediment concentrations and discharges in streams within the AOSERP study area.
Funding: $9 000.00

Modelling the Circulation and Sediment Distribution in the Athabasca Delta Area

This system will provide a calibrated mathematical model capable of predicting the circulation patterns in the southwest end of Lake Athabasca and of indicating concentration distributions under various flow conditions. It will also relate LANDSAT imagery to water quality parameters, primarily suspended sediment concentrations.
Funding: $90 000.00

Oil Sands In Situ Combustion Products

This project was undertaken to chemically identify contaminants in the produced fluids and gases of in situ fire-flood produced bitumen, and to identify the possible environmental hazards and human health risks arising from these toxic and carcinogenic materials.
Funding: $100 000.00 (Jointly funded by AOSTRA and the Research Management Division)

Oil Sands Tailings Geomechanics

The objective of this project is to determine the nature and extent of oil sand tailings generation, materials balance, sludge behaviour, systems properties, and potentially beneficial treatments from a geomechanics and systems analysis point of view.
Funding: This project is currently at the proposal stage.

Processing and Analysis of Cold Lake Seismicity Data

This project was initiated to obtain data reduction and analysis services for digital seismic data derived from the Cold Lake Digital Seismic Array. A further objective was to initiate research into induced seismicity phenomena associated with in situ extraction of bitumen from the Alberta Oil Sands.

Funding: $25 000.00 (Grant from Esso Resources to the University of Alberta)

Study of the California and Other Water Atlas Projects and Proposal for an Alberta Water Atlas Study

The objective of this project is to study the recently-completed California Water Atlas project, as well as other projects for which reference materials are available in California and Alberta, to determine what alternative procedures and methods might be used to develop a Water Atlas of Alberta and to prepare an Alberta Water Atlas proposal. This proposal will include tentative tables of contents with comments on the options available, outlines of alternative development procedures, and estimates of cost.

Funding: $9 200.00

Water Quality Monitoring in the Athabasca Oil Sands Area

The objective of this project is to collect water quality data in the Athabasca Oil Sands area. The data provide a continuous set of baseline information for the region.

Funding: $150 000.00

PUBLICATIONS

Akena, A.M. and L.L. Christian. 1981. Water quality of the Athabasca oil sands area. Vol. IV: an interim compilation of non-AOSERP water quality data. Prep. for Research Management Division by Alberta Environment. RMD Report L-74. 242 pp.

Crowther, R.A. and B.J. Lade. 1980. An assessment of benthic secondary production in the Muskeg River of northeastern Alberta. Prep. for Alberta Environment, Alberta Oil Sands Environmental Program by IEC International Environmental Consultants Ltd. AOSERP Report 116. 106 pp.

Hickman, M., C.E.D. Charlton, and C.J. Jenkerson. 1981. A longitudinal physico-chemical and algal survey of five rivers flowing through the AOSERP study area. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by the University of Alberta, Department of Botany. RMD Report OF-28.

Mayhood, D.W. 1982. Chemical and biological monitoring of muskeg drainage at the Alsands project site. Vol. III: program evaluation and suggestions for continued monitoring. Prep. for Alsands Energy Limited by Aquatic Environments Limited. RMD Report OF-39. 35 pp.

Mayhood, D.W. and L.D. Corkum. 1982. Chemical and biological monitoring drainage at the Alsands project site. Vol. II. Prep. for Alberta Environment and Alsands Energy Limited by Aquatic Environment Limited and Hardy Associates (1978) Limited. RMD Report OF-38. 295 pp.

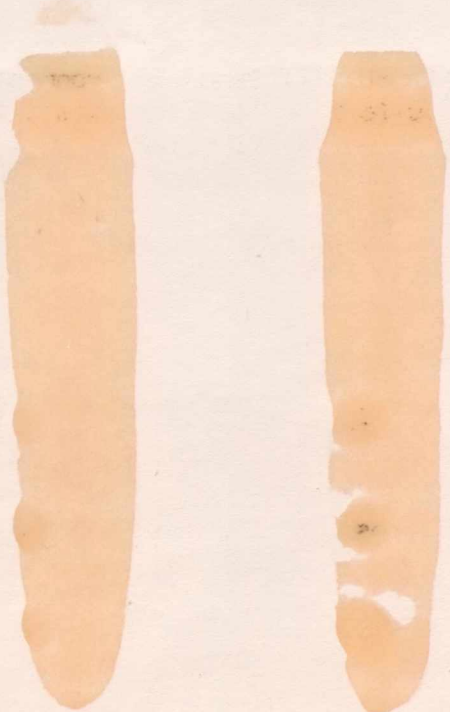
Neill, C.R., B.J. Evans, and A.W. Lipsett. 1981. Circulation of water and sediment in the Athabasca delta area. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Northwest Hydraulic Consultants Ltd. and the Alberta Research Council. AOSERP Report 123. 182 pp.

Nix, P.G., D.W.S. Westlake, R.T. Coutts, and F.M. Pasutto. 1981. The metabolism of selected organic compounds by microorganisms in the Athabasca River. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research program by C & G Labs Ltd. AOSERP Report 121. 97 pp.

Sekerak, A.D. and G.L. Walder. 1980. Aquatic biophysical inventory of major tributaries in the AOSERP study area. Vol. I: summary report. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by LGL Limited, Environmental Research Associates. AOSERP Report 114. 100 pp.

Tsui, P.T.P., B.R. McMahon, P.J. McCart, and J.V. McCart. 1980. A laboratory study of long-term effects of mine depressurization groundwater on fish and invertebrates. Prep. for Alberta Environment, Alberta Oil Sands Environmental Research Program by Aquatic Environments Ltd. AOSERP Report 113. 211 pp.

Yau, H., K.L. Murphy, and P.L. Timpany. 1982. Athabasca River modelling studies (Phase I) for Fort McMurray-Embarras. Prep. for Alberta Environment, Research Management Division by Intenational Environmental Consultants. RMD Report L-76. 101 pp.



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12. Very high resolution meteorological satellite study of oil sands weather: "a feasibility study". 1977.
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16. The feasibility of a weather radar near Fort McMurray, Alberta. 1977.

17. A survey of baseline levels of contaminants in aquatic biota of the AOSERP study area. 1977.

18. Interim compilation of stream gauging data to December 1976 for AOSERP. 1977.

19. Calculations of annual averaged sulphur dioxide concentrations at ground level in the AOSERP study area. 1977.

20. Characterization of organic constituents in waters and wastewaters of the Athabasca oil sands mining area. 1978.

21. AOSERP second annual report, 1976-77. 1977.

22. AOSERP interim report covering the period April 1975 to November 1978. 1979.

23. Acute lethality of mine depressurization water to trout-perch and rainbow trout: Volume I: 1979.

24. Air system winter field study in the AOSERP study area, February 1977. 1979.

25. Review of pollutant transformation processes relevant to the Alberta oil sands area. 1977.

26. Interim report on an intensive study of the fish fauna of the Muskeg River watershed of northeastern Alberta. 1977.

27. Meteorology and air quality winter field study in the AOSERP study area, March 1976.

28. Interim report on a soils inventory in the Athabasca oil sands area. 1978.

29. An inventory system for atmospheric emissions in the AOSERP study area. 1978.

30. Ambient air quality in the AOSERP study area. 1977.

31. Ecological habitat mapping of the AOSERP study area: Phase I. 1978.

32. AOSERP third annual report, 1977-78.

33. Relationships between habitats, forages, and carrying capacity of moose range in northern Alberta. Part I: moose preferences for habitat strata and forages. 1978.

34. Heavy metals in bottom sediments of the mainstem Athabasca River system in the AOSERP study area. 1978.

35. The effects of sedimentation on the aquatic biota. 1978.

36. Fall fisheries investigations in the Athabasca and Clearwater rivers upstream of Fort McMurray: Volume I. 1978.

37. Community studies: Fort McMurray, Anzac, Fort MacKay. 1978.

38. Techniques for the control of small mammal damage to plants: a review. 1979.

39. The climatology of the AOSERP study area. 1979.

40. Mixing characteristics of the Athabasca River below Fort McMurray--winter conditions. 1979.

41. Acute and chronic toxicity of vanadium to fish. 1978.

42. Analysis of fur production records for registered traplines in the AOSERP study area, 1970-75. 1978.

43. A socio-economic evaluation of the recreational use of fish and wildlife resources in Alberta, with particular reference to the AOSERP study area. Vol. I: summary and conclusions. 1979.

44. Interim report on symptomology and threshold levels of air pollutant injury to vegetation, 1975 to 1978. 1979.

45. Interim report on physiology and mechanisms of air-borne pollutant injury to vegetation, 1975 to 1978. 1979.

46. Interim report on ecological benchmarking and biomonitoring for detection of air-borne pollutant effects on vegetation and soils, 1975 to 1978.

47. A visibility bias model for aerial surveys of moose in the AOSERP study area. 1979.

48. Interim report on a hydrogeological investigation of the Muskeg River basin, Alberta. 1979.

49. The ecology of macrobenthic invertebrate communities in Hartley Creek, northeastern Alberta. 1979.

50. Literature review on pollution deposition processes. 1979.

51. Interim compilation of 1976 suspended sediment data for the AOSERP study area. 1979.

52. Plume dispersion measurements from an oil sands extraction plant, June 1977. 1979.

53. Baseline states of organic constituents in the Athabasca River system upstream of Fort McMurray. 1979.

54. A preliminary study of chemical and microbial characteristics of the Athabasca River in the Athabasca oil sands area of northeastern Alberta. 1979.

55. Microbial populations in the Athabasca River. 1979.

57. Ecological habitat mapping of the AOSERP study area (supplement): Phase I. 1979.

58. Interim report on ecological studies on the lower trophic levels of Muskeg rivers within the AOSERP study area. 1979.

59. Semi-aquatic mammals: annotated bibliography. 1979.

60. Synthesis of surface water hydrology. 1979.

61. An intensive study of the fish fauna of the Steepbank River watershed of northeastern Alberta. 1979.

62. Amphibians and reptiles in the AOSERP study area. 1979.

63. Analysis of AOSERP plume sigma data. 1979.

64. A review and assessment of the baseline data relevant to the impacts of oil sands developments on large mammals in the AOSERP study area. 1979.

65. A review and assessment of the baseline data relevant to the impacts of oil sands development on black bear in the AOSERP study area. 1979.

66. An assessment of the models LIRAQ and ADPIC for application to the Alberta oil sands area. 1979.

67. Aquatic biological investigations of the Muskeg River watershed. 1979.

68. Air system summer field study in the AOSERP study area, June 1977.

69. Native employment patterns in Alberta's Athabasca oil sands region. 1979.

70. An interim report on the insectivorous animals in the AOSERP study area. 1979.

71. Lake acidification potential in the AOSERP study area. 1979.

72. The ecology of five major species of small mammals in the AOSERP study area: a review. 1979.

73. Distribution, abundance, and habitat associations of beavers, muskrats, mink, and river otters in the AOSERP study area, northeastern Alberta. 1979.

74. Air quality modelling and user needs. 1979.

75. Interim report on a comparative study of benthic algal primary productivity in the AOSERP study area. 1979.

76. An intensive study of the fish fauna of the Muskeg River watershed of northeastern Alberta. 1979.

77. Overview of local economic development in the Athabasca oil sands region since 1961. 1979.

78. Habitat relationships and management of terrestrial birds in northeastern Alberta. 1979.

79. The multiple toxicity of vanadium, nickel, and phenol to fish. 1979.

80. History of the Athabasca oil sands region, 1890 to 1960's. Volume I: socio-economic developments. Volume II: oral history. 1980.

81. Species distribution and habitat relationships of waterfowl in northeastern Alberta. 1979.

82. Breeding distribution and behaviour of the white pelican in the Athabasca oil sands area. 1979.

83. The distribution, foraging behaviour and allied activities of the white pelican in the Athabasca oil sands area. 1979.

84. Investigations of the spring spawning fish populations in the Athabasca and Clearwater rivers upstream from Fort McMurray: Volume I. 1979.

85. An intensive surface water quality study of the Muskeg River watershed. Volume I: water chemistry. 1979.

86. An observational study of fog in the AOSERP study area. 1979.

87. Hydrogeological investigation of Muskeg River basin, Alberta. 1980.

88. Ecological studies of the aquatic invertebrates of the AOSERP study area of northeastern Alberta. 1980.

89. Fishery resources of the Athabasca River downstream of Fort McMurray, Alberta: Volume I. 1980.

90. A wintertime investigation of the deposition of pollutants around an isolated power plant in northern Alberta. 1980.

91. Characterization of stored peat in the Alberta oil sands area. 1980.

92. Fisheries and habitat investigations of tributary streams in the southern portion of the AOSERP study area. Volume I: summary and conclusions. 1980.

93. Fisheries and aquatic habitat investigations in the MacKay River watershed of northeastern Alberta. 1980.

94. A fisheries and water quality survey of ten lakes in the Richardson Tower area, northeastern Alberta. Volume I: methodology, summary, and discussion. 1980.

95. Evaluation of the effects of convection on plume behaviour in AOSERP study area. 1980.

96. Service delivery in the Athabasca oil sands region since 1961. 1980.

97. Differences in the composition of soils under open and canopy conditions at two sites close-in to the Great Canadian Oil Sands Operation, Fort McMurray, Alberta. 1980.

98. Baseline condition of jack pine biomonitoring plots in the Athabasca oil sands area: 1976-77.

99. Synecology and autecology of boreal forest vegetation in the AOSERP study area. 1980.

100. Baseline inventory of aquatic of aquatic macrophyte species distributions in the AOSERP study area. 1980.

101. Woodland caribou population dynamics in northeastern Alberta. 1980.

102. Wolf population dynamics and prey relationships in northeastern Alberta. 1980.

103. Analysis of the leisure delivery system 1972-1979, with projections for future servicing requirements. 1980.

104. Review of requirements for air quality simulation models. 1980.

105. Approaches to the design of a biomonitoring program using arthropods as bioindicators for the AOSERP study area. 1980.

106. Meteorological factors affecting ambient SO_2 concentrations near an oil sands extraction plant. 1980.

107. Small mammal populations of northeastern Alberta. Volume I: populations in natural habitats. 1980.

108. Small mammal populations of northeastern Alberta. Volume II: populations in reclamation areas. 1980.

109. Symptomology and threshold levels of air pollutant injury to vegetation, 1979-80. 1980.

110. Physiology and mechanisms of airborne pollutant injury to vegetation, 1979-80. 1980.

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112. A study of human adjustment in Fort McMurray. Volume I: field study and results. 1980.

113. A laboratory study of long-term effects of mine depressurization groundwater on fish and invertebrates. 1980.

114. Aquatic biophysical inventory of major tributaries in the AOSERP study area. Volume I: summary report. 1980.

115. Report on an ecological survey of terrestrial insect communities in the AOSERP study area. 1980.

116. An assessment of benthic secondary production in the Muskeg River of northeastern Alberta. 1980.

117. Development of a chemically reactive plume model for application in the AOSERP study area. 1980.

118. Alberta Oil Sands Environmental Research Program, 1975-1980. A summary report. 1981.

119. Airshed management system for the Alberta oil sands. Volume I: A Gaussian frequency distribution model. 1981.

120. Airshed management system for the Alberta oil sands. Volume II: meteorological data.

121. The metabolism of selected organic compounds by microorganisms in the Athabasca River. 1981.

122. Soils inventory of the AOSERP study area. 1982.

123. Circulation of water and sediment in the Athabasca delta area. 1981.

124. Airshed management system for the Alberta oil sands. Volume III: validation and sensitivity studies. 1982.

125. The 1981 snowpack survey in the AOSERP study area. 1981.

126. Modelling the topographic effects on winds in the Alberta oil sands area. 1982.

127. Alberta Oil Sands Environmental Research Program annual report 1981/82. 1983.

128. A comparative study of benthic algal primary productivity in the AOSERP study area. 1982.

129. Athabasca Oil Sands precipitation chemistry studies: 1976-79 and 1981. 1982.

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM REVIEW FOR THE FISCAL YEAR 1983/84

AOSERP Report 132

Alberta
ENVIRONMENT
Environmental Protection Services
Research Management Division

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM REVIEW FOR THE FISCAL YEAR 1983/84

RESEARCH MANAGEMENT DIVISION
Alberta Environment

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ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

AOSERP Report 132

1986

TABLE OF CONTENTS

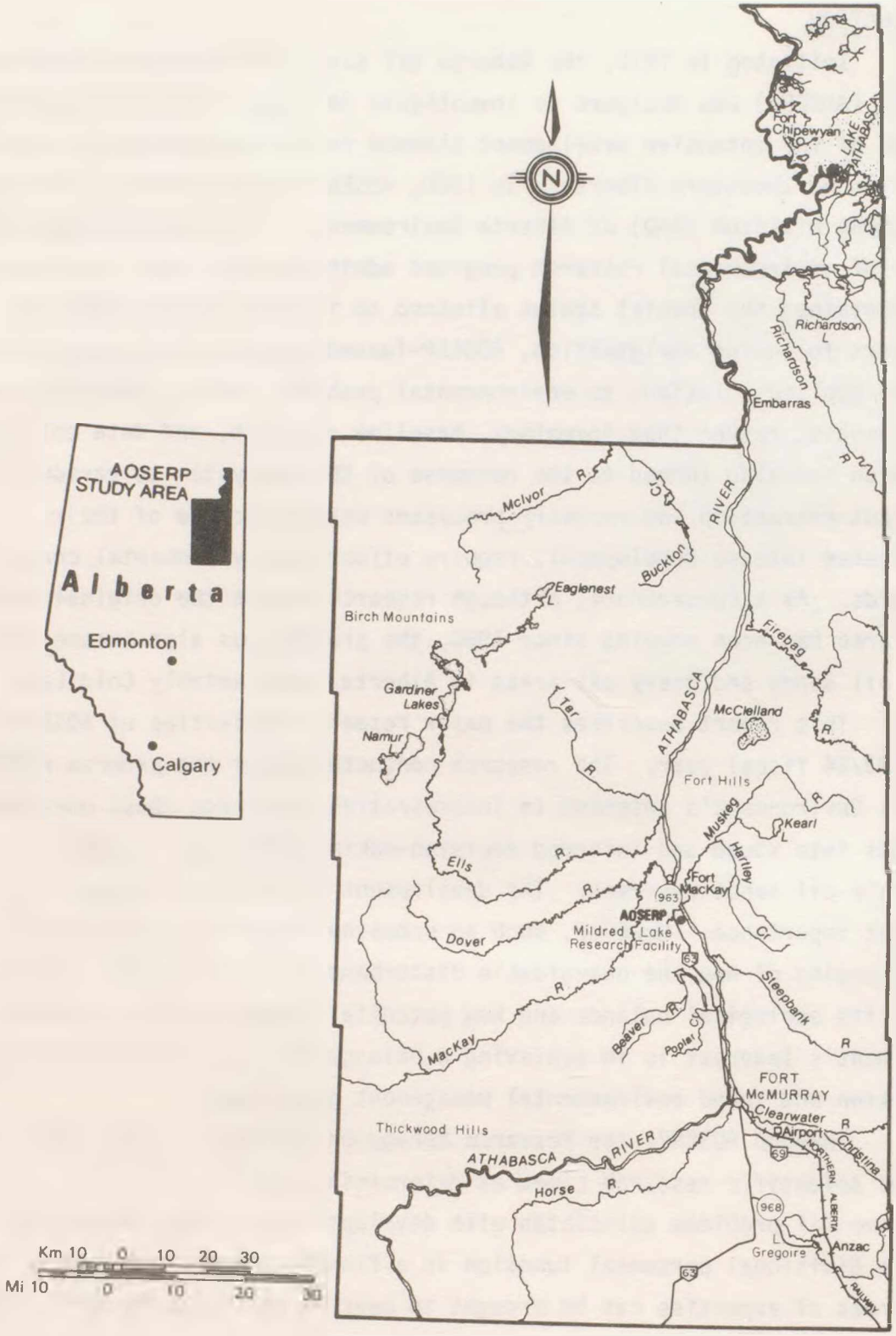
	Page
INTRODUCTION	1
ENVIRONMENTAL EFFECTS OF ATMOSPHERIC EMISSIONS	4
Projects	6
Publications	13
EFFECTS OF ENERGY PRODUCTION ON HUMANS	15
Projects	16
Publications	17
ENVIRONMENTAL CONSEQUENCES OF IN SITU EXTRACTION TECHNOLOGY	18
Projects	19
Publications	21
LAND RECLAMATION	22
Projects	24
Publications	26
CUMULATIVE LIST OF AOSERP PUBLICATIONS TITLES	27

INTRODUCTION

Initiated in 1975, the Alberta Oil Sands Environmental Research Program (AOSERP) was designed to investigate the potential environmental effects of the intensive development planned for the Athabasca Oil Sands region in northeastern Alberta. In 1980, AOSERP was absorbed by the Research Management Division (RMD) of Alberta Environment. The program became one of a number of environmental research programs administered by the division, but has maintained the special status allotted to it prior to amalgamation. In the years following amalgamation, AOSERP-funded research has expanded to address applied solutions to environmental problems arising from oil sands developments, rather than inventory, baseline research, and data collection. Attention has also turned to the response of the ecosystem to various in situ oil sands extraction and recovery processes which, because of their anticipated intense development, require effective environmental control standards. As a consequence, although research within the original AOSERP study area has been ongoing since 1980, the program has also become active in other oil sands and heavy oil areas in Alberta, most notably Cold Lake.

This report describes the major research activities of AOSERP during the 1983/84 fiscal year. The research conducted under the program reflects Alberta Environment's interest in incorporating knowledge about environmental problems into sound and informed decision-making about the recovery of Alberta's oil sands reserves. The development of this vast energy resource is of great importance. However, such an endeavour must be guided by an understanding of how the unavoidable disturbances to the natural environment affect its ecological balance and how potential damage can be mitigated. The Department's interest is in achieving a balance between efficient energy production and sound environmental management practices.

Through AOSERP, the Research Management Division funds, manages, and reviews scientific research aimed at determining applied solutions to environmental problems associated with development of energy resources. Because divisional personnel function in a flexible matrix management system, many areas of expertise can be brought to bear in the planning and designing



Location of the original AOSERP study area.

of environmental research projects. Disciplines represented by the division include climatology, pedology, biology, ecology, sociology, and hydrology. Staff members also act as a scientific resource for various government agencies and industries concerned with oil sands development.

Support for AOSERP is provided by a camp and laboratory at Mildred Lake, located north of Fort McMurray. The Mildred Lake facility is designed as a base for environmental research within an area that is directly affected by oil sands development. It is used by both large and small consulting firms and private energy companies, as well as by a number of governmental and other agencies.

The following report is divided into four sections, each addressing a major research area in which projects were funded under AOSERP. These areas are:

1. The environmental effects of atmospheric emissions;
2. The environmental consequences of in situ extraction technologies;
3. The effects of energy production on humans; and
4. Land reclamation.

ENVIRONMENTAL EFFECTS OF ATMOSPHERIC EMISSIONS

The Acid Deposition Research Program was designed to plan and implement research specific to Alberta that would concisely address the following objectives:

1. To characterize sensitive environmental ecosystems and develop methodologies to identify and/or predict measurable short- and long-term effects of acidic or acidifying substances on Alberta ecosystems;
2. To determine the characteristics and quantities of both long-range emissions and those generated locally, and to examine their effects on the environment;
3. To develop a basis and approach for preventive strategies and environmental protection; and
4. To co-ordinate departmental research on acid deposition with other private and public agencies in Alberta and the rest of Western Canada.

In 1983/84, work on acidic and acidifying substances concentrated on characterizing and quantifying their ecological effects. Such research continued to be a major activity in the Division. Considerable effort was expended to develop a more thorough understanding of the atmosphere-biosphere interface. A newly developed model shows great promise for simulating this relationship.

The emission of acid forming substances into the atmosphere and their deposition and subsequent impact on the ecosystem are of significant concern. Because the magnitude and intensity of deposition is irregular and sporadic, the response of vegetation to pollution episodes is dependent upon the relationship and timing of the incident and the physiological development of the receptor. Specific projects have been geared to the accurate and frequent measurements of pollutant concentration occurrences and their interface with physiological, phenological, and productivity responses in vegetation species. Data generated will be used to develop a computerized numerical model for integrating chronic air pollutant exposures and tree growth response. A second major interface, between soil nutrients, microbiological processes, and vegetation, is also being studied.

Regional surveys to sample and chemically analyse event rainfall and the snowpack for total pollutant loadings in the Athabasca Oil Sands region were continued. Wet deposition, however, is only one of two major mechanisms in the transfer of pollutants from source to receptor. Air pollutants released into the atmosphere are deposited continuously and cumulatively through both dry- and wetfall processes. Methodologies and instrumentation technology for measuring dry deposition were developed and implemented in the field.

In conjunction with the aforementioned studies, research to determine the transport, dispersion, and transformation rates of oxides of sulphur and nitrogen emissions was continued. Such research is intended to facilitate the investigation of the medium- to long-range transport of acid forming emissions from a major emission source in the area.

The Acid Deposition Research Program will provide scientific information for reviewing and evaluating Alberta's air quality standards, will assist in current and future planning of industrial development, and will enable a good understanding of the potential for environmental acidification. This program will thereby establish a basis for sound, long-term environmental management. The data collected will be used in the development of methodologies that will identify and/or predict environmental deterioration caused by acid forming emissions.

The Research Management Division played a major role in the planning, development, and co-ordination of a major new program in Alberta during 1983/84, the Alberta Government/Industry Acid Deposition Research Program (AGIADRP). This important program is sponsored and managed on a fifty-fifty basis by government and industry, and has an estimated budget of $8 million over the next seven years. The planning and development of subsequent phases of the departmental Acid Deposition Research Program, managed by the Research Management Division, will be integrated and co-ordinated with AGIADRP.

PROJECTS

Air Quality Data Acquisition

The emission of acid forming substances into the atmosphere and their deposition and subsequent impact on the ecosystem are of current concern. The magnitude and intensity of deposition follows an episodic pattern; however, the response of vegetation to pollution is dependent upon the relationship and timing of the episode and the physiological development of the receptor. Therefore air quality/atmospheric data must be interfaced with receptor response measurements.

To facilitate the implementation of an ecological monitoring research program, an air quality monitoring station was established in the vicinity of a permanent sample plot on the Sandalta lease in the Athabasca Oil Sands area. The station continuously measures meteorological data and ambient concentrations of acid forming gases, and takes integrated measurements of wet- and dryfall particulate matter. Data generated will be used to develop numerical models for interfacing air quality/atmospheric data to plant response measurements.

An interim report will be available from the Research Management Division.

Contractor: D.S. Chadder, PROMET Environmental Group Ltd.

Funding: $70 000.00 (Research Management Division)

Chemistry of Summer Precipitation in the Athabasca Oil Sands Area

Atmospheric pollutants are scavenged from the air by rainfall. Analysis of this rain provides some indication of the amount and distribution of chemical elements and components that are present in the air. Projects to collect and chemically analyse rainfall on an event basis have been ongoing since 1976 in the Athabasca Oil Sands area. Emissions from industrial sources in this region are under careful scrutiny. Concern is that these parameters would change in space and time as a result of additional atmospheric emission sources. The continued monitoring will delineate any possible changes in the nature and spatial distribution of wetfall deposition from these sources.

Objectives of the study are to:

1. Identify trends in the chemical characteristics of rainfall;
2. Develop the most appropriate and successful sampling and analysis techniques for precipitation chemistry; and
3. Provide a data base to quantify changes in the input rate of atmospheric trace substances into sensitive ecosystems.

Contractor: D.S. Chadder, PROMET Environmental Group Ltd.
E. Peake, Kananaskis Centre for Environmental Research
N. Das, Alberta Environmental Centre

Funding: $56 000.00 (Research Management Division)

Chemistry of Winter Precipitation in the Athabasca Oil Sands Area

As an ongoing project since 1976, the accumulated snowpack in the Athabasca Oil Sands area has been extensively sampled and chemically analysed. The principal objectives of the project have been to quantify the total ionic and particulate loading of the snowpack and to qualitatively assess the spatial distribution of pollutant deposition resulting from the emissions from industrial sources in the area. This information will provide the baseline data required to assess the impact of future industrial developments in the area. Developmental research work was also implemented that would investigate the chemical composition of meltwater and the fractionation of ions during snowmelt.

Contractor: D. LaBerge, CHEMEX Labs (Alberta) Ltd.

Funding: $40 000.00 (Research Management Division)

Determination of Dispersion, Pollutant Trajectories, and Precipitation-Acidifying Processes through Aircraft Measurements

Initiated in 1982 as a co-operative effort between the Alberta Research Council and the Research Management Division, the project investigates the dispersion and transport of sulphur dioxide and oxides of nitrogen from point source plumes in the oil sands area near Fort McMurray. The chemical transformation and rate of removal of these acid forming emissions by both clouds and precipitation will also be investigated. The airborne field measurements will provide baseline information for future

pollutant trend analyses and will be vitally important for tracking pollutant/air mass trajectories from the emission sources.

An interim report will be available from the Research Management Division.

Contractor: M. English and L. Cheng, Alberta Research Council

Funding: $50 000.00 (Research Management Division)
$50 000.00 (Alberta Research Council)

Determination of the Roughness Length in the Athabasca Oil Sands Region

The Gaussian frequency distribution model developed for the Research Management Division provides a reasonable approximation of the ground level concentrations (g.l.c.) of pollutants emitted into the atmospheric boundary layer from point sources. Roughness length (Z_o), a measure of how much mechanical mixing is generated by wind blowing over a particular surface, is a key variable in the model. The location and magnitude of the g.l.c. can therefore be altered with slight variations in Z_o.

The purpose of the project is to increase the reliability of the Gaussian model by determining a more representative value for Z_o for the oil sands area. The model will then be a more powerful tool for reliably predicting ground level concentrations of pollutants. To facilitate this, the project will

1. Empirically estimate Z_o from existing minisonde and acoustic sounder data collected in the AOSERP area by matching the lower portion of the wind profile to the logarithmic law profile; and
2. Evaluate the feasibility of using aircraft-derived measurements to estimate Z_o. Aircraft-derived Z_o values will be correlated with empirically derived values to ascertain the validity and reliability of this technique.

Contractor: R. Rudolph, INTERA Technologies Ltd.

Funding: $44 000.00 (Research Management Division)

Dry Deposition of Acid Forming Emissions in Alberta

The measurement of acid forming emissions deposition relies on two components: wet- and dryfall accumulation. In Alberta, dry deposition is

considered to be at least as important as wet deposition; unfortunately, dry deposition rates are not well documented. This project, currently being conducted in the Athabasca Oil Sands area, will continuously measure ambient concentrations of sulphur dioxide and collect integrated data on the quality and quantity of dry- and wetfall particulate matter. This study will promote the development and field testing of measurement techniques for the dry deposition of sulphur dioxide and the subsequent derivation of dry deposition velocities.

The project is a specific component of an integrated research effort to assess the impact of total acid deposition on terrestrial ecosystems. It will provide the information necessary to assess the total deposition occurring in the vicinity of an oil sands plant and to define source-receptor relationships.

An interim report will be available from the Research Management Division.

Contractor: D.S. Chadder, PROMET Environmental Group Ltd.

Funding: $87 000.00 (Research Management Division)

Effects of Deposition of Acid Forming Substances on Nutrient Cycling in a Forest Ecosystem

The effects of deposition of acid forming substances on (1) nutrient release from decomposing litter; (2) distribution and leaching characteristics of key nutrients in the litter/soil system; and (3) the uptake of nutrients by mycorrhizal and non-mycorrhizal jackpine seedlings will be studied.

The first annual report is available from the Research Management Division,

Contractor: D. Parkinson, University of Calgary

Funding: $40 688.00 (Research Management Division)

Effects of Deposition of Acid Forming Substances on Organic Matter Decomposition and Microbial Activity

This study will investigate organic matter transformations in the litter layer of jackpine woodland ecosystems under different levels of impact from acid forming emission substances. Sampling of litter fall, decomposition

rates, biological activity, and total microbial biomass will be done. Major reactions in carbon (energy) flow are to be measured and correlated with the impact of the acid forming substances.

The first annual report is available from the Research Management Division.

Contractor: D. Parkinson, University of Calgary

Funding: $29 159.00 (Research Management Division)

The Effects of Nitrogen Oxides on Native Vegetation, Soils, and Water near a Compressor Installation

The sensitivity of select natural plant species to injury by low concentrations of nitrogen oxide and/or nitrogen dioxide stress was determined. Also examined were the effects of nitrogen oxides on the availability of certain plant nutrients in the soil. These studies will be integrated with the compressor station-ecosystem distribution inventory for Alberta, as well as with information on known emissions of oxides of nitrogen.

A final report will be available from the Research Management Division late in 1985.

Contractor: A. Legge, University of Calgary

Funding: $95 000.00 (Research Management Division)
$30 000.00 (Standards and Approvals Division)

Impacts of Air Pollutant Mixtures on Forest Vegetation and Soils

The study is designed to use both laboratory and field investigations to identify and quantify forest tree responses to single and multiple exposures of acid forming pollutants. For the Athabasca Oil Sands area, a predictive capability for changes in forest soils and vegetation will be developed. Both current and future rates of pollution deposition are being considered.

Annual reports are available from the Research Management Division.

Contractor: P. Addison, Canadian Forestry Service

Funding: $30 000.00 (Research Management Division)

Nutrient Redistribution in Jackpine as an Indication of Acid Deposition Stress

The feasibility of using non-destructive analytical methods to detect changes in tree wood chemistry is being examined. Tree cores will be analysed for temporal nutrient changes related to the emissions from oil sands plants in the Fort McMurray area.

A final report will be available from the Research Management Division late in 1985.

Contractor: A. Legge, University of Calgary

Funding: $40 800.00 (Research Management Division)

Protection of the Biotic Environment

This study evaluated the relative effects of natural and anthropogenic (pollutants) factors on forest ecosystems. Morphologic and growth responses (past and present) in jackpine and aspen stands throughout the Athabasca Oil Sands were studied to determine if pollution effects can be identified and quantified. The research was carried out under the auspices of an Alberta Oil Sands Technology and Research Authority Professorship.

The final report is in preparation.

Contractor: C. Pielou, University of Lethbridge

Funding: $38 308.00 (Grant to University of Lethbridge Professorship) (Research Management Division)

$14 100.00 (Research contract) (Research Management Division)

The Response of Vegetation Communities to Aerial Emissions

This project will determine structural dynamics in the boreal forest in order to compare any natural changes to those induced by aerial emissions. Results from this project will be used, in conjunction with findings from other studies, to develop sensitive and predictive indicators of effects of aerial emissions on forest ecosystems (as an early warning). This study will involve process-related phenomena and will establish the relationship between changes occurring in these processes and the structure and function of terrestrial ecosystem. This project has been integrated with other terrestrial studies.

Annual reports are available from the Research Management Division.

Contractor: G. LaRoi, University of Alberta

Funding: $87 508.50 (Research Management Division)

PUBLICATIONS

Case, J.W. 1983. **Biomonitoring of air pollution in Alberta with lichens and mosses.** Prep. for Alberta Environment, Research Management Division. RMD Report OF-52. 154 pp.

Colley, D.G., R.W. Poon, M.J. Zelensky, and L. Zanzotto. 1984. **Alberta oxides of nitrogen emissions forecast 1980 to 2000.** Prep. for Alberta Environment, Research Management Division by Western Research, Division of Bow Valley Resources Ltd. RMD Report 84/26. 101 pp.

Krouse, H.R. and J.W. Case. 1983. **Sulphur isotope abundances in the Alberta Oil Sands Environmental Research Program study area.** Prep. for Alberta Oil Sands Environmental Research Program by University of Calgary Interdisciplinary Sulphur Research Group (UNISUL) and Department of Physics, University of Calgary. RMD Report OF-55. 99 pp.

Krouse, H.R. and J.W. Case. 1984. **Design, development, and field testing of a mobile nine unit high volume air sampler array.** Prep. for Alberta Environment, Research Management Division by Physics Department, University of Calgary. RMD Report OF-69. 45 pp.

LaRoi, G.H. and M. Ostafichuk. 1983. **Structural dynamics of boreal forest ecosystems on three habitat types in the Hondo-Lesser Slave Lake area of north-central Alberta in 1981.** Prep. for Alberta Environment, Research Management Division by Department of Botany, University of Alberta. RMD Report OF-64. 110 pp.

LaRoi, G.H., M.S. Ross, and M. Ostafichuk. 1983. **Structural dynamics of boreal forest ecosystems on three habitat types in the Hondo-Lesser Slave Lake area of north-central Alberta in 1982. Volume I: Text; Volume II: Appendix.** Prep. for Alberta Environment, Research Management Division by Department of Botany, University of Alberta. RMD Report OF-65. 2 vols.

Nosal, M. 1984. **Atmosphere-biosphere interface: probability analysis and an experimental design for studies of air pollutant-induced plant response.** Prep. for Alberta Environment, Research Management Division by Statistical Research Laboratory, University of Calgary and Statscon, Statistical Consulting Co. RMD Report 83/25. 98 pp.

Ostafichuk, M. and G.H. LaRoi. 1983. **Progress report for 1982: Pinus banksiana-dominated permanent sample plots in the Athabasca Oil Sands.** Prep. for Alberta Environment, Research Management Division by Department of Botany, University of Alberta. RMD Report OF-66. 189 pp.

Sandhu, H.S. and R.P. Angle. 1984. **Air quality and acid rain: an overview.** 26 pp. (Paper prep. for "Impacts of Science and Technology on Environments," a lecture series organized by Edmonton Public School Board.)

EFFECTS OF ENERGY PRODUCTION ON HUMANS

During 1983/84, research into the effects of energy production on humans focused on the effects of plant closures on resource communities and on public involvement in environmental decision-making.

A project that researched the effects of plant closures on a single-resource community was completed during the year. This project assessed the socio-economic impacts of plant closures on the quality of life of individuals and families and covered a wide range of social and economic indicators.

A comprehensive literature search and a review of current techniques for public involvement strategies in water resource management was undertaken for the Community Affairs Branch of the Environmental Assessment Division. This provided background for an evaluation of the public involvement component of the Beaver River-Cold Lake Water Management Study. The report primarily dealt with data from 1978 to 1983.

PROJECTS

Effects of Plant Closures: Phase I

An assessment of the socio-economic impacts of plant closures on the quality of life of individuals and families within the community of Brooks was completed. Analysis of the data provided the basis for recommendations concerning long- and short-term strategies to reduce the socio-economic impacts of future closures.

Contractor: Anna Parkinson Urban Consultants Ltd.

Funding: $34 500.00 (Research Management Division)

Population Turnover in Fort McMurray: Phase II

A questionnaire identifying why people moved from resource towns was designed and pre-tested in Phase I. Implementation of that questionnaire to former residents of Fort McMurray will identify why people move from resource towns.

Contractor: Thames Group Research

Funding: None in 1983

PUBLICATIONS

Krahn, H. 1984. **Labour market segmentation in Fort McMurray**. Prep. for Alberta Environment, Research Management Division by Department of Sociology, University of Alberta. RMD Report OF-71. 329 pp. (Ph.D. thesis)

ENVIRONMENTAL CONSEQUENCES OF IN SITU EXTRACTION TECHNOLOGY

The research emphasis of the aquatic component of AOSERP during 1983/84 addressed the potential effects on surface and groundwater resources of in situ oil sands extraction and recovery. There were three major areas of investigation:

1. The most extensive research involved a regional assessment of the hydrological and hydrochemical characteristics of the Cold Lake Oil Sands deposit, where a steam injection pilot plant has been operated by Esso Resources for several years and a potential production facility is in the final planning stage.
2. A companion project monitored the location and cause of seismic events in the Cold Lake area. The objective of this project was to provide detailed baseline data to monitor the in situ steam injection process and determine if it was contributing to ground deformation and/or movement.
3. The third project identified the toxic and carcinogenic products that are generated by several different in situ processes.

The objective of each of these projects is to evaluate the possible environmental hazards and human health risks associated with in situ oil sands recovery processes. The synthesis of the results from these studies will provide the Department with the integrated environmental information necessary for making informed management decisions for the safe environmental development of oil sands resources by in situ extraction and recovery processes.

PROJECTS

Analysis of Aquatic Monitoring Data in the Athabasca Oil Sands Area

The objective of this project was to analyse the relationship between water quality and benthic invertebrate data based on samples collected during monitoring programs carried out on the Athabasca River. Specifically, this task involved the use of multivariate statistical analysis to: (1) evaluate which few water quality parameters of the many measured would be useful in long-term monitoring programs designed to detect municipal and industrial impacts; and (2) determine if water quality parameters could be used to predict the distribution and abundance of benthic invertebrates at sites within the study area.

Contractor: Dr. G. Walder, Sigma Biometrics

Funding: $15 000.00 (Research Management Division)

International Conference on Oil and Fresh Water: Chemistry, Biology, and Technology

This grant contributed to the organization and presentation of a major international conference on oil pollution of fresh water, held on 1984 October 15-19. The conference brought together experts from the disciplines of chemistry, biology, and engineering. By means of invited and contributed papers, it served as a review of all available and current research on oil pollution of freshwater systems. Special attention was given to contamination resulting from oil spills, synthetic crude oil production, and industrial/urban runoff.

Contractor: Dr. S.E. Hrudey, University of Alberta

Funding: $10 000.00 (Research Management Division) (Grant)

Oil Sands In Situ Combustion Products

This project was undertaken to identify contaminants in the fluids and gases associated with in situ fire-flood produced bitumen, and identify the possible environmental hazards and human health risks arising from these toxic and carcinogenic materials.

Contractor: E. Peake, Kananaskis Centre for Environmental Research, University of Calgary

Funding: $50 000.00 (Research Management Division)
$50 000.00 (Alberta Oil Sands Technology Research Authority)

A Regional Assessment of Hydrogeological and Hydrochemical Conditions in the Cold Lake Oil Sands Deposit

This project is an integral part of the Department's effort to assess the extent and quality of groundwater resources in the Cold Lake region to protect the resources from contamination by industrial activity. At present, no technology exists for a quantitative prediction of the potential regional-scale effects of lost process or wastewaters on a pre-existing groundwater regime in three dimensions in the presence of high pressure, high temperature steam injected in a widely distributed pattern of boreholes. This project seeks to establish such a technology through the development of a three-dimensional framework of tne hydrostratigraphy, hydrodynamics, and hydrochemistry of the Cold Lake Oil Sands area. It will also identify the processes inherent to both in situ recovery and deep waste disposal methods, and will evaluate their possible effects on both local and regional groundwater regimes. Recommendations will be made for further study aimed at the quantification of these potential impacts on both local and regional scales.

Contractor: Dr. G. Gabert, Alberta Research Council

Funding: $229 000.00 (Research Management Division)
$104 607.00 (Alberta Research Council)

PUBLICATIONS

Andres, D.D. In prep. **The hydraulic erodability of cohesive materials.** Alberta Research Council, Internal Report SWE 83-04.

Andres, D.D. and P.F. Doyle. 1983. **Analysis of breakup and ice jams on the Athabasca River at Fort McMurray, Alberta.** Submitted to the Canadian Journal of Civil Engineering. Alberta Research Council, Contribution Series Paper 1214.

Boerger, H. 1983. **Distribution and abundance of macrobenthos in the Athabasca River near Fort McMurray.** Prep. for Alberta Environment, Research Management Division by Department of Physics, University of Calgary. RMD Report OF-53. 77 pp.

Elhadi, N., R.A. Harrington, I. Hill, Y.L. Lau, and B.G. Krishnappan. 1983. **River mixing: a state-of-the-art report.** Accepted for publication in the Canadian Journal of Civil Engineering.

Hudson, H.R. 1983. **Discussion of bedload and size distribution in a paved gravel bed stream.** Submitted to Journal of Hydraulic Engineering, ASCE. Alberta Research Council, Contribution Series Paper 1155.

Hudson, H.R. In prep. **Fluvial sediment yield in Alberta. IN: Proceedings of the Soil Erosion and Land Degradation Conference.** November 1983; Saskatoon, Saskatchewan.

Hudson, H.R. In prep. **Sediment yield research in Alberta.** Alberta Research Council, Internal Report SWE 83-05.

Hudson, H.R. 1984. **Aspects of the hydrologic and sediment regimes of the Muskeg River Basin and the consequences of vegetation removal.** Prep. for Alberta Environment, Research Management Division by Department of Civil Engineering, Alberta Research Council. RMD Report L-84. 46 pp.

LAND RECLAMATION

Petroleum extraction from oil sands causes several reclamation problems, the most serious being current tailings disposal systems. At the end of its 25-year life cycle, a typical oil sands plant producing 19 900 m^3 (125 000 barrels) per day of synthetic crude oil will require a 22 to 31 km^2 tailings pond. The 360 000 000 m^3 of sludge in the pond will remain liquid indefinitely, and must be impounded behind tailings sand dykes 55 to 100 m high. A cover of grasses, legumes, and shrubs will provide erosion protection. Since tailings sand lacks nutrients and drains excessively rapidly, it must be amended with peat and mineral fines to initiate soil development. Extensive areas of overburden dumps and flat tailings sand must also be reclaimed to various land uses.

Research into the reclamation requirements of oil sands development is aimed at defining techniques whereby a self-sustaining, erosion-free cover can be established on tailings sand dykes, and tailings sands storage and overburden dumps can be returned to productive forest. The resulting soil and plant community combinations must not only fulfill these land use requirements, but must also sustain themselves without indefinite maintenance.

The regulation of surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council, which oversees reclamation research programs. To assist in technical matters related to the development and administration of research programs, the Council appointed the Reclamation Research Technical Advisory Committee (RRTAC), which consists of eight members representing the departments of Agriculture, Energy and Natural Resources, and Environment, and the Alberta Research Council. The Research Management Division represents Alberta Environment on RRTAC and provides project managers and administrative support for many of the projects in this program.

To pool resources and avoid duplication, RRTAC and the industry's Oil Sands Industry Environmental Association (OSIEA) have initiated a joint Reclamation Research Program for oil sands areas. Three priorities have been identified: (1) woody plant research, (2) soil reconstruction, and (3) equipment development.

The Woody Plant Research Program is now underway, and test plots for the Soil Reconstruction Research Program have been prepared. Some initial work on choice and modification of existing equipment has been done as part of the Soil Reconstruction Research Program.

PROJECTS

Mycorrhizal Development on Severely Disturbed Soils

This study examined the potential of natural inoculum in stored peat and developed effective mycorrhizal associations for oil sands reclamation.

Four reports to be published in 1985 will describe the nature and rate of micro-organism establishment in mine spoils and the influence of various reclamation treatments in creating a stable plant-soil system.

Contractor: D. Parkinson, University of Calgary

Funding: $86 140.00 (Land Conservation and Reclamation Council-Heritage Savings Trust Fund)

Oil Sands Tailings Soil Reconstruction

Using the results of a study undertaken to determine the minimum physical, chemical, and biological properties of soil required to support three vegetation types, a joint government-industry reclamation project was initiated to identify methods of reconstructing soils from tailings sand, peat, and clayey materials that will support a self-maintaining woody shrub and tree cover. A flat tailings sand experimental site was constructed on the Syncrude Canada Ltd. lease at Fort McMurray.

Fifty-four plots, 22 m wide and 44 m long, were created. Treatments included: (1) three organic carbon levels provided by mixing peat into the tailings sand; (2) three levels of clay provided by mixing fine-textured overburden into the tailings sand; and (3) two mixing depths.

Baseline soil data have been collected and 10 tree and shrub species were planted in the fall of 1984.

Contractor: H. Martens, Hardy Associates (1978) Ltd.

Funding: $108 106.00 (Land Conservation and Reclamation Council-Heritage Savings Trust Fund)

$108 106.00 (Syncrude Canada Ltd., Suncor Inc., and the Oil Sands Industry Environmental Association)

International Inventory of Fertility Analysis for Peat Soils

Peat fertility is a poorly understood subject that has received minimal investigation in North America. Under the auspices of the International Peat Society, an RMD scientist has compiled an international inventory of peat analysis methods used by research institutes where more relevant research has been carried out. The inventory will be used to help develop standard international methodology for peat analysis.

Funding: None in 1983/84

Reclamation Research Review

International reclamation literature is being collected by RMD staff and compiled in a bibliography. A computer program has been developed to allow users to search the bibliography. The data base is kept on a SPIRES file at the University of Alberta. An additional 800 references were added to the computer data base in 1983/84.

Divisional staff prepared a synthesis of literature referenced in the bibliography. This report was published in March 1984, and provides direction for further research in the province.

Funding: $17 500.00 (Land Conservation and Reclamation Council-Heritage Savings Trust Fund)
15 341.00 (Research Management Division)

PUBLICATIONS

Monenco Consultants Ltd. 1983. **Soil reconstruction design for the reclamation of oil sands tailings.** Prep. by Monenco Consultants Ltd. for the Oil Sands Environmental Study Group and Alberta Land Conservation and Reclamation Council. Report No. OSESG-RRTAC 83-1. 196 pp. (Available from Queen's Printer.)

Sims, H.P., C.B. Powter, and J.A. Campbell. 1984. **Land surface reclamation: a review of international literature.** Prep. for Alberta Land Conservation and Reclamation Council by Research Management Division. Report No. RRTAC 84-1. 2 vols. 1549 pp. (Available from Queen's Printer.)

Zak, J.C. and D. Parkinson. 1983. Effects of surface amendation of two mine spoils in Alberta, Canada, on vesicular-arbuscular mycorrhizal development of slender wheatgrass: a 4-year study. Canadian Journal of Botany 61:788-803.

CUMULATIVE LIST OF AOSERP PUBLICATIONS TITLES

1. AOSERP First Annual Report, 1975
2. Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta - 1975
3. Structure of a Traditional Baseline Data System
4. A Preliminary Vegetation Survey of the AOSERP Study Area
5. The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6. Housing for the North. The Stackwall System Construction Report - Mildred Lake Tank and Pump House
7. A Synopsis of the Physical and Biological Limnology and Fishery Programs within the Alberta Oil Sands Area
8. The Impact of Saline Waters upon Freshwater Biota. A Literature Review and Bibliography
9. A Preliminary Investigation into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10. Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11. Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12. Very High Solution Meteorological Satellite Study of Oil Sands Weather: A Feasibility Study
13. Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14. (No report published)
15. A Climatology of Low-Level Air Trajectories in the Alberta Oil Sands Area
16. The Feasibility of a Weather Radar near Fort McMurray, Alberta
17. A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18 Interim Compilation of Stream Gauging Data to December 1976 for AOSERP
19. Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area

20. Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area

21. AOSERP Second Annual Report, 1976-77

22. AOSERP Interim Report Covering the Period April 1975 to November 1978

23. Acute Lethality of Mine Depressurization Water to Trout-Perch and Rainbow Trout: Volume I

24. Air System Winter Field Study in the AOSERP Study Area, February 1977

25. Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta

27. Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976

28. Interim Report on a Soils Inventory in the Athabasca Oil Sands Area

29. An Inventory System for Atmospheric Emissions in the AOSERP Study Area

30. Ambient Air Quality in the AOSERP Study Area

31. Ecological Habitat Mapping of the AOSERP Study Area: Phase I

32. AOSERP Third Annual Report, 1977-78

33. Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in Northern Alberta. Part 1: Moose Preferences for Habitat Strata and Forages

34. Heavy Metals in Bottom Sediments of the Mainstem Athabasca River Upstream of Fort McMurray: Volume I

35. The Effects of Sedimentation on the Aquatic Biota

36. Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I

37. Community Studies: Fort McMurray, Anzac, and Fort MacKay

38. Techniques for the Control of Small Mammal Damage to Plants: A Review

39. The Climatology of the AOSERP Study Area

40. Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions

41. Acute and Chronic Toxicity of Vanadium to Fish

42. Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-1975

43. A Socio-Economic Evaluation of the Recreational Use of Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume I: Summary and Conclusions

44. Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978

45. Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978

46. Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978

47. A Visibility Bias Model for Aerial Surveys of Moose in the AOSERP Study Area

48. Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta

49. The Ecology of Macrobenthic Invertebrate Communities in Harley Creek, Northeastern Alberta

50. Literature Review on Pollution Deposition Processes

51. Interim Compilation of 1976 Suspended Sediment Data for the AOSERP Study Area

52. Plume Dispersion Measurements from an Oil Sands Extraction Plant, June 1977

53. Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray

54. A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta

55. Microbial Populations in the Athabasca River

56. The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates

57. Ecological Habitat Mapping of the AOSERP Study Area (supplement). Phase 1

58. Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers within the AOSERP Study Area

59. Semi-Aquatic Mammals: Annotated Bibliography

60. Synthesis of Surface Water Hydrology

61. An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta

62. Amphibians and Reptiles in the AOSERP Study Area

63. Analysis of AOSERP Plume Sigma Data

64. A Review and Assessment of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area

65. A Review and Assessment of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area

66. An Assessment of the Models LIRAQ and ADPIC for Application to the Alberta Oil Sands Area

67. Aquatic Biological Investigations of the Muskeg River Watershed

68. Air System Summer Field Study in the AOSERP Study Area, June 1977

69. Native Employment Patterns in Alberta's Athabasca Oil Sands Region

70. An Interim Report on the Insectivorous Animals in the AOSERP Study Area

71. Lake Acidification Potential in the AOSERP Study Area

72. The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review

73. Distribution, Abundance, and Habitat Associations of Beavers, Muskrats, Mink, and River Otters in the AOSERP Study Area, Northeastern Alberta

74. Air Quality Modelling and User Needs

75. Interim Report on a Comparative Study of Benthic Algal Primary Productivity in the AOSERP Study Area

76. An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta

77. Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1976

78. Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta

79. The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish

80. History of the Athabasca Oil Sands Region, 1890 to 1960s. Volume I: Socio-Economic Development; Volume II: Oral History

81. Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta

82. Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area

83. The Distribution, Foraging Behaviour and Allied Activities of the White Pelican in the Athabasca Oil Sands Area

84. Investigations of the Spring Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray: Volume I

85. An Intensive Surface Water Quality Study of the Muskeg River Watershed. Volume I: Water Chemistry

86. An Observational Study of Fog in the AOSERP Study Area

87. Hydrogeological Investigation of the Muskeg River Basin, Alberta

88. Ecological Studies of the Aquatic Invertebrates of the AOSERP Study Area of Northeastern Alberta

89. Fishery Resources of the Athabasca River Downstream of Fort McMurray, Alberta: Volume I

90. A Wintertime Investigation of the Deposition of Pollutants around an Isolated Power Plant in Northern Alberta

91. Characterization of Stored Peat in the Alberta Oil Sands Area

92. Fisheries and Habitat Investigations of Tributary Streams in the Southern Portion of the AOSERP Study Area: Volume I

93. Fisheries and Aquatic Habitat Investigations in the Mackay River Watershed of Northeastern Alberta

94. A Fisheries and Water Quality Survey of Ten Lakes in the Richardson Tower Area, Northeastern Alberta. Volume I: Methodology, Summary, and Discussion

95. Evaluation of the Effects of Convection on Plume Behaviour in the AOSERP Study Area

96. Service Delivery in the Athabasca Oil Sands Region since 1961

97. Differences in the Composition of Soils under Open and Canopy Conditions at Two Sites Close-In to the Great Canadian Oil Sands Operation, Fort McMurray, Alberta

98. Baseline Condition of Jack Pine Biomonitoring Plots in the Athabasca Oil Sands Area: 1976-1977

99. Synecology and Autecology of Boreal Forest Vegetation in the AOSERP Study Area

100. Baseline Inventory of Aquatic Macrophyte Species Distributions in the AOSERP Study Area

101. Woodland Caribou Population Dynamics in Northeastern Alberta

102. Wolf Population Dynamics and Prey Relationships in Northeastern Alberta

103. Analysis of the Leisure Delivery System 1972-1979, with Projections for Future Servicing Requirements

104. Review of Requirements for Air Quality Simulation Models

105. Approaches to the Design of a Biomonitoring Program Using Arthropods as Bioindicators for the AOSERP Study Area

106. Meteorological Factors Affecting Ambient SO_2 Concentrations near an Oil Sands Extraction Plant

107. Small Mammal Populations of Northeastern Alberta. Volume I: Populations in Natural Habitats

108. Small Mammal Populations of Northeastern Alberta. Volume II: Populations in Reclamation Areas

109. Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1979-1980

110. Physiology and Mechanisms of Airborne Pollutant Injury to Vegetation, 1979-1980

111. Ecological Benchmarking and Biomonitoring for Detection of Airborne Pollutant Effects of Vegetation and Soils

112. A Study of Human Adjustment in Fort McMurray. Volume I: Field Study and Results

113. A Laboratory Study of Long-Term Effects of Mine Depressurization Groundwater on Fish and Invertebrates

114. Aquatic Biophysical Inventory of Major Tributaries in the AOSERP Study Area. Volume I: Summary Report

115. Report on an Ecological Survey of Terrestrial Insect Communities in the AOSERP Study Area

116. An Assessment of Benthic Secondary Production in the Muskeg River of Northeastern Alberta

117. Development of a Chemically Reactive Plume Model for Application in the AOSERP Study Area

118. Alberta Oil Sands Environmental Research Program, 1975-1980. A Summary Report

119. Airshed Management System for the Alberta Oil Sands Area. Volume I: A Gaussian Frequency Distribution Model

120. Airshed Management System for the Alberta Oil Sands Area. Volume II: Meteorological Data

121. The Metabolism of Selected Organic Compounds by Microorganisms in the Athabasca River

122. Soil Inventory of the AOSERP Study Area

123. Circulation of Water and Sediment in the Athabasca Delta Area, 1981

124. Airshed Management System for the Alberta Oil Sands. Volume III: Validation and Sensitivity Studies

125. The 1981 Snowpack Survey in the AOSERP Study Area

126. Modelling Topographic Effects on Winds in the Alberta Oil Sands Area

127. Alberta Oil Sands Environmental Research Program Annual Report for the Fiscal Year 1981/82

128. A Comparative Study of Benthic Algal Primary Productivity in the AOSERP Study Area

129. Athabasca Oil Sands Precipitation Chemistry Studies: 1976-1979 and 1981

130. Climatological Analysis of Recent Data from the Athabasca Oil Sands Area

131. Annual Report 1982/83. Alberta Oil Sands Environmental Research Program