Annual Report 1982/83 Alberta Oil Sands Environmental Research Program

AOSERP Report 131

Alberta

ENVIRONMENT
Environmental Protection Services

RESEARCH MANAGEMENT DIVISION LOGO

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 ANNUAL REPORT 1982/83

AOSERP Report 131

Alberta
ENVIRONMENT
Research Management Division
14th Floor, Standard Life Centre
10405 Jasper Avenue,
Edmonton, Alberta, Canada

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 AOSERP 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:

Research Management Division
Publications Office
14th Floor, Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4
(403) 427-3946

Alberta Oil Sands Environmental Research Program

Annual Report 1982/83

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This report may be cited as:

Research Management Division. 1983. Alberta Oil Sands Environmental Research Program Annual Report 1982/83. Prep. by Alberta Oil Sands Environmental Research Program for the Research Management Division. AOSERP Report 131. 29 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 1982/83."

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

Respectfully,

Walter Solodzuk, P.Eng.
Deputy Minister, Alberta Environment

ALBERTA OIL SANDS ENVIRONMENTAL

RESEARCH PROGRAM

ANNUAL REPORT 1982/83

Research Management Division
Alberta Oil Sands Environmental
Research Program

AOSERP Report 131

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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 (Figure 1). In 1980, AOSERP was absorbed by the Research Management Division (RMD) of Alberta Environment. The program became one of several environmental research programs administered by the division, but has maintained the special status allotted to it prior to amalgamation.

Also in 1980, a five-year summary report on AOSERP[1] recommended a re-direction of the purpose and scope of the program. As a result, AOSERP-funded research was expanded to address applied solutions to environmental problems arising from oil sands developments, rather than focus on inventory, baseline research, and data collection. Attention was 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 study within the original AOSERP study areas has been ongoing since 1980, the program has also become active in other oil sands areas in Alberta, most notably Cold Lake.

This report describes the major research activities of AOSERP during the 1982/83 budget 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

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[1] S.B. Smith. 1981. Alberta Oil Sands Environmental Research Program, 1975 to 1980: summary report. Prep. by Research Management Division and S.B. Smith Environmental Consultants Ltd. AOSERP Report 118. 170 pp.

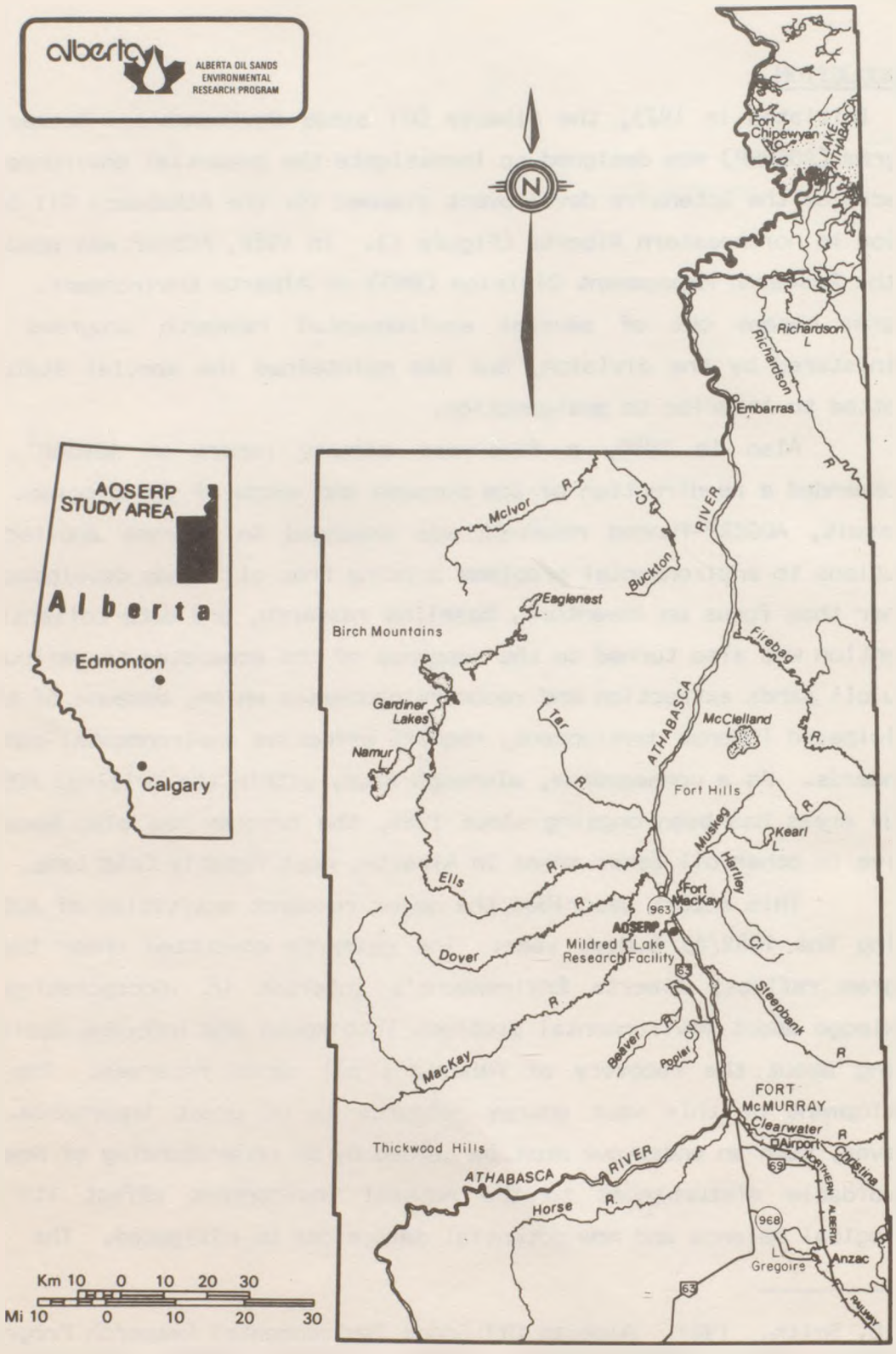

Figure 1. Original AOSERP study area.

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 are organized by a flexible matrix management system, many areas of expertise can be brought to bear in the planning and designing 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 to various government agencies and to industries concerned with oil sands development.

Support for AOSERP is provided by a camp and laboratory at Mildred Lake, north of Fort McMurray. The Mildred Lake facility is designed as a base for environmental research within an area which 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. Easy access to the research area and the excellence of the facilities at Mildred Lake have encouraged its high use. During the reporting year, 3612 meals were served and 1134 man-nights spent at the camp. One third of this use was for research unassociated with RMD contracts.

Table 1 shows funding of AOSERP during the past three years. Monies spent on environmental research projects have remained relatively constant over this period. This consistency reflects the division's success in maximizing its research dollars by decreasing its administrative costs.

The following report is divided into four sections, each addressing a major research area undertaken by 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.

Table 1. Total funds committed to AOSERP, 1980 to 1983.

	1980/81	1981/82	1982/83
Administration	$ 694 000.00	$ 582 532.00	$ 375 745.00
Projects	$1 170 550.00	$1 438 607.00	$1 519 574.00
Grants	$ 38 000.00	$ 30 000.00	0
Assets	$ 97 450.00	$ 41 000.00	22 000.00
TOTAL	$2 000 000.00	$2 092 139.00	$1 917 319.00

Those wishing more information on the scientific research described in this report are encouraged to contact the Director of the Research Management Division. Technical research reports may be ordered from the Publications Officer, Research Management Division.

THE ENVIRONMENTAL EFFECTS OF ATMOSPHERIC EMISSIONS

In 1982/83, the emphasis changed in the assessment of the possible environmental effects of acid-forming emissions resulting from activities of the petro-chemical industry in the oil sands region. Past research projects had been initiated to generate baseline information on (1) atmospheric/deposition processes; and (2) sensitivity of terrestrial and aquatic ecosystems to pollutant deposition. In 1982/83, the emphasis on the ecological effects of acid-forming emissions continued. However, a high priority was also given to the integration of existing and new research activities in order to facilitate a more thorough understanding of the relationships between the atmosphere and the biosphere.

The specific objective in 1982/83 was to design an integrated research program to identify, characterize, and quantify definitive changes in the ecosystem as a result of exposure to air pollution. Because of the significant implications for ecological monitoring of pollution impact, specific projects were geared to the accurate and frequent measurement of the episodicity of pollutant concentrations and their interface with physiological, phenological, and productivity responses in vegetation species at the plant process, whole plant, and population levels. The corresponding interface with soil nutrient and microbiological processes was also studied.

Regional surveys to sample and chemically analyse event rainfall and the snowpack for total pollutant loadings in the Athabasca Oil Sands area were continued. A satisfactory sulphur deposition model was developed to estimate deposition patterns around selected emission sources. Wet deposition, however, is only one of two major and equally important 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. Hence, the development of methodologies and instrumentation technology for measuring the dry deposition of sulphur dioxide was initiated. Implementation and field testing of measurement techniques will be carried out in the oil sands area during the 1983 summer field season.

In conjunction with the studies mentioned above, research was undertaken to investigate the medium- to long-range transport of acid-forming emissions from a major emission source in the area. The objectives of the study were to determine the transport, dispersion, and transformation rates of oxides of sulphur and nitrogen emissions.

This research program will provide scientific information for reviewing and evaluating Alberta's air quality standards, and will assist in the present and future planning of industrial development. Finally, it will provide a good understanding of the potential for environmental acidification and aid in the development of methodologies to identify and/or predict environmental deterioration caused by acid-forming emissions, thereby aiding sound, long-term environmental management.

PROJECTS

Ambient Air Quality

This project provided sound air quality monitoring data for use in determining the effects of aerial pollutant emissions on soil and vegetation processes. The monitoring site was approximately 20 km from the Syncrude and Suncor sites in the Athabasca Oil Sands region, and was a focus for several related studies relevant to ongoing investigations of the response of vegetation communities to aerial emissions.
Funding: $19 113.00

Chemistry of Summer Precipitation in the Athabasca Oil Sands Area

Pollutants that are deposited by precipitation provide some indication of the amount and distribution of chemical elements and compounds that are present in the air. Sources of these chemical constituents can be either anthropogenic or natural background.

To attempt an accurate determination of the chemical additives in rain, an ongoing sampling project was carried out to collect rainfall on an event basis in the original AOSERP study area. A chemical analysis will be performed and the major anions and cations in the samples will be quantified.
Funding: $8 726.00

Chemistry of Winter Precipitation in the Athabasca Oil Sands Area

As part of an ongoing project, the accumulated snowpack in the original AOSERP area was extensively sampled and chemically analysed. The concentrations of the ionic and insoluble particulate constituents were determined. Deposition patterns and spatial variability of snowpack contaminant loadings were also studied to provide baseline data for future industrial development.
Funding: N/A (In House)

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

Through aircraft measurements, the pollutant dispersion coefficient, pollution trajectories, and precipitation-acidifying processes of sulphur dioxide emissions in the Athabasca Oil Sands area were determined. The project was initiated during the 1982/83 budget year, and will continue for three years.

Funding: $94 554.00 (Jointly funded by Research Management Division and Alberta Research Council)

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 information on known emissions of oxides of nitrogen.

Funding: $169 800.00 (Jointly funded by the Research Management Division and the Pollution Control Division)

Impact of Air Pollutant Mixtures Characteristic of the Athabasca Oil Sands Region on Forest Vegetation and Soils

This study investigated the effects on forest vegetation and soils of air pollutant mixtures characteristic of the oil sands region. The project was a joint research effort with the Canadian Forestry Service.

Funding: $43 585.00

The Response of Vegetation Communities to Aerial Emissions

This project determined structural dynamics in the boreal forest and compared any natural changes to those possibly 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 aerial emissions (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 the terrestrial ecosystem. This project has been integrated with other terrestrial studies.
Funding: $35 820.00

A Review of the Technology Available for the Control of Atmospheric Emissions from Oil Sands Plants

This project provided an overview of the technology available for the control of atmospheric emissions of sulphur dioxide and nitrogen oxides from oil sands plants. A review of established technology for the extraction and upgrading of oil sands bitumen and the potential application of these processes to an oil sands plant was provided. Consideration was given to the capacities of individual processes. In addition, the development that is required in a typical oil sands context and to fix the basis of the process economics were extrapolated.
Funding: $76 058.83

Update of the Physical Climatology of the Athabasca Oil Sands Region

Since 1976, the Research Management Division has been involved in the collection of meteorological data from nine stations (MAPS network) in the Athabasca Oil Sands region of northeastern Alberta. A previous study (Longley and Janz), which synthesized available long-term climate records, presented a descriptive overview of the area's climate. With the automated MAPS network coming on stream in late 1976, a more comprehensive data base became available. The objective of the present study was to update and synthesize the long-term climate data for the region, incorporating the short-term data records from the MAPS network.
Funding: $36 700.00

THE ENVIRONMENTAL CONSEQUENCES OF IN SITU EXTRACTION TECHNOLOGY

The research emphasis of the aquatic component of AOSERP during 1982/83 addressed the potential effects on surface and groundwater resources of in situ oil sands extraction and recovery. There were three major areas of investigation.

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. 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. The third project chemically identified the toxic and carcinogenic products which were 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 to making informed management decisions for the safe environmental development of oil sands resources by in situ extraction and recovery processes.

PROJECTS

Cold Lake Seismic Array

This project provided baseline seismicity information in the Cold Lake Oil Sands area. Further objectives were: (1) to identify the source locations of observed seismic events and to identify or suggest their causes; (2) to describe the environmental significance of observed seismic events and their relationship to current activities; (3) to make recommendations concerning ongoing monitoring after the basic study is completed; and (4) to design mitigative engineering features. Operation of the array and the dissemination of data continue to be carried out by the Earth Sciences Division, Alberta Environment.

Funding: None in 1982/83

Processing and Analysis of Cold Lake Seismicity Data

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

Funding: $25 000.00 (Funded by a grant from Esso Resources Ltd. to the University of Alberta)

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

This project is a integral to the department's effort to assess the extent and quality of groundwater resources in the Cold Lake region and to protect the resources from contamination by industrial activity. At present, no technology exists for a quantitative prediction of the potential regional effects of lost process or wastewaters on a pre-existing groundwater regime (in three dimensions and 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 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 both local and regional groundwater regimes. Recommendations will be made for further study aimed at the quantification of these potential impacts at both local and regional scales.

Funding: $250 000.00 (Research Management Division, Alberta Environment)
$304 000.00 (Alberta Research Council)

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: $50 000.00 (Research Management Division, Alberta Environment)
$50 000.00 (AOSTRA)

THE EFFECTS OF ENERGY PRODUCTION ON HUMANS

During 1982/83, research into the effects of energy production on humans focussed on human and biophysical relationships. A major concern has also been social impact assessment and public participation in environmental issues. Following the recommendations in the "1975-1985: Summary Report," research was aimed at understanding the social processes associated with energy production rather than accumulating data from diverse sources.

Phase I of a study of "Population Turnover in Fort McMurray" was completed. The majority of persons who participated in the 1979 study of "Family Adjustment in Fort McMurray" were located and a comprehensive questionnaire was designed and pre-tested.

Preliminary research was begun on the effects of plant closures on resource communities. In order to select a location which would provide optimum data, demographic and economic parameters were evaluated. The project will assess the socio-economic impacts of plant closures on the quality of life of individuals and families within an as yet undetermined community in Alberta. The appropriate social and economic issues will be decided upon by a thorough review of secondary data sources and through interviews with community leaders.

Background documentation and initial project rationales were developed for research into the cumulative impacts of multi-energy developments. This is an exploratory study designed to identify the effects of several types of energy-related developments taking place at one time in a particular community.

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 Athabasca Oil Sands region due to the development of the area's resources. This project will provide a synthesis of the data collected to date.
Funding: None in 1982/83.

Policy Analysis of Fort McMurray Data

Data collected in a 1979 field 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 northeastern Alberta. Policy options data were provided by the New Town Planning Board. The re-interpreted information is intended to be used for future planning.
Funding: None in 1982/83

Population Turnover in Fort McMurray: Phase I

People who participated in the 1979 study, "Family Adjustment in Fort McMurray," and who had since moved away were located. A substantial questionnaire which would identify reasons why people move from resource towns was designed and pre-tested.
Funding: $32 225.00

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 (8.5 to 12.0 mi^2) tailings pond. The 36 000 000 m^3 (1 271 160 000 cu. ft.) of sludge in the pond will remain liquid indefinitely and must be impounded behind tailings sand dykes 55 to 100 m (180.5 x 329.0 ft.) 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 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), consisting 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 Environmental Study Group (OSESG) 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 under way 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

Compilation of International Peat Analysis Methods

Peat fertility is a poorly understood subject that has received minimal investigation in North America. Under the auspices of the International Peat Society, a scientist from RMD is compiling an inventory of peat analysis methods from international research institutes where more relevant research has been carried out. The inventory will be used to help develop standard international methodology for peat analysis. This standardization will assist in planning and evaluating the use of peat as an amendment in soil reconstruction over tailings sand.

Funding: $8 000.00

Mycorrhizal Potential in Reconstructed Soils

Mycorrhizal fungi are very important to the nutrition of trees. This project will determine the survival and inoculum potential of mycorrhizal fungi in undisturbed and stockpiled peat to be used in oil sands tailings reclamation. Also, fungal species will be selected for use in Jack Pine inoculation programs and mycorrhizal development will be monitored in field trials.

Funding: $116 700.00 (Funded by RRTAC)

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 870 references were added to the computer data base in 1982/83.

Divisional staff are preparing a synthesis of literature referenced in the bibliography. This report will provide direction for further research in the province.

Funding: $11 000.000 (Funded by the Land Conservation and Reclamation Council-Heritage Trust Savings Fund)

Soil Reconstruction: Phase I Literature Review

This was a joint OSESG/RRTAC project aimed at identifying available soil-building materials in the Athabasca Oil Sands area and developing methods of combining these materials into productive soils. Phase I, which is a literature review and analysis of existing information, was funded in 1979/80. This review identified treatments for the Test Plot Program which will constitute Phase II of the Soil Reconstruction Project.

Funding: None in 1982/83 (Jointly funded by RRTAC and OSESG)

Soil Reconstruction: Phase II Test Plot Construction and Plant Propagation

Information from the preceding literature review is being used in this study to design reconstructed soils. This study is to test the effect of soil variables on woody plant performance, and the long- and short-term stability and survival of the soil/plant system.

Funding: None in 1982/83

Woody Plant Establishment and Management Program

This project is co-funded equally by the provincial government and the Oil Sands Environmental Study Group (OSESG). It is one of a series of literature surveys leading up to establishment of field trials in the oil sands.

Funding: $14 950.00 (Jointly funded by RRTAC and OSESG)

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1. AOSERP first annual report, 1975. 1976.

2. Walleye and goldeye fisheries investigations in the Peace-Athabasca Delta--1975. 1976.

3. Structure of a traditional baseline data system. 1976.

4. A preliminary vegetation survey of the AOSERP study area. 1976.

5. The evaluation of wastewaters from an oil sand extraction plant. 1976.

6. Housing for the north--the stackwall system; construction report--Mildred Lake tank and pump house. 1976.

7. A synopsis of the physical and biological limnology and fishery programs within the Alberta oil sands area. 1977.

8. The impact of saline waters upon freshwater biota (a literature review and bibliography). 1977.

9. A preliminary investigation into the magnitude of fog occurrence and associated problems in the oil sands area. 1977.

10. Development of a research design related to archaeological studies in the Athabasca oil sands area. 1977.

11. Life cycles of some common aquatic insects of the Athabasca River, Alberta. 1977.

12. Very high resolution meteorological satellite study of oil sands weather: "a feasibility study." 1977.

13. Plume dispersion measurements from an oil sands extraction plant, March 1976. 1977.

14. No report published.

15. A climatology of low-level air trajectories in the Alberta oil sands area. 1977.

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.

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

22. AOSERP interim report covering the period of 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.

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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 1. 1978.

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. 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 1. 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.

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