Inventory of Water Use Requirements and Effluent Discharge Characteristics Related to Oil Sands Development

Project WS 1.2.2

June 1980

Alberta
ENVIRONMENT

15th Floor, Oxbridge Place
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Edmonton, Alberta, Canada
T5K 2J6

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

RESEARCH REPORTS

These research reports describe the results of investigations funded under 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.

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and Effluent Discharge Characteristics
Related to Oil Sands Development

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This report may be cited as:

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The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

Sir:

Enclosed is the report "Inventory of Water Use Requirements and Effluent Discharge Characteristics Related to Oil Sands Development".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its Water System, under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

W. Solodzuk, P.Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

INVENTORY OF WATER USE REQUIREMENTS AND EFFLUENT DISCHARGE CHARACTERISTICS RELATED TO OIL SANDS DEVELOPMENT

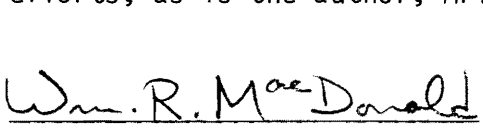
DESCRIPTIVE SUMMARY

BACKGROUND

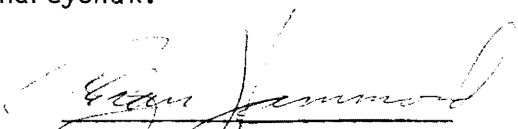
Water withdrawal and effluent discharge characteristics are a matter of record through normal government licencing channels. This information has been regard as essential in order to properly conduct such research thrusts as aquatic toxicology and river assimilation modelling. However, there were difficulties in obtaining the desired information because of its diverse nature and the various repositories. Accordingly, this project was intended to collect and tabulate actual water withdrawal and effluent discharge characteristics. A statement of objectives for the project is found in the introduction.

ASSESSMENT

The report has been reviewed by managers both in Alberta Environment Water Quality Branch and Suncor, Inc. It presents a very extensive compilation of water quality and quantity data and no doubt will be most valuable to researchers and managers alike. The Alberta Oil Sands Environmental Research Program accepts the report "Inventory of Water Use Requirements and Effluent Discharge Characteristics Related to Oil Sands Development" and we recommend that it be distributed to selected Canadian Libraries. The various government agencies and the oil sands industries that provided information are thanked for their efforts, as is the author, Mr. A.P. Andreychuk.



W.R. MacDonald, Ph.D
Director (1980-81)
Alberta Oil Sands Environmental
Research Program



B.R. Hammond, Ph.D
Research Manager
Water System

INVENTORY OF WATER USE REQUIREMENTS AND EFFLUENT DISCHARGE CHARACTERISTICS RELATED TO OIL SANDS DEVELOPMENT

by

A.P. Andreychuk
Stanley Associates Engineering Ltd.

for

ALBERTA OIL SANDS
ENVIRONMENTAL RESEARCH PROGRAM

Project WS 1.2.2

June 1980

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ABSTRACT

An inventory of historical data on water use requirements and effluent discharge characteristics related to oil sands developments has been collected and tabulated.

The inventory data indicate that surface water bodies are the main sources of the water supply and main recipients of effluent. Since the Athabasca River is the principal surface water associated with these functions, a water balance was developed which accounted for all the major withdrawals and discharges to this river. Currently, the annual rate of withdrawal from the Athabasca River downstream of Fort McMurray is 2.34 m^3/s. The amount of effluent discharge to the Athabasca River is 0.89 m^3/s, which indicates a yearly balance of 38% return.

With respect to the water quality of the Athabasca River, the inventory data provide an historical summary of the quality, quantity, and some plant operational details associated with each of the oil sands developments. With the aid of additional information, the inventory data may be used in assessing the existing and predicting the future water quality of the Athabasca River.

An evaluation of a number of data management systems revealed that Computer Sciences Canada Ltd. and their MANAGE data base management system ranked the highest in providing the needs associated with water quality and quantity management.

ACKNOWLEDGEMENTS

This research project WS 1.2.2 was funded by the Alberta Oil Sands Environmental Research Program, established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta.

1. INTRODUCTION

The current mining and refining operations associated with Athabasca Oil Sands developments require large volumes of water and may discharge domestic and industrial wastewater to adjacent watercourses. The volumes, physical and chemical characteristics of freshwater required, and the wastewater produced depend on the location of the mine and the process employed in recovering the oil from the sand. In addition, mine depressurization water, a wastewater associated with mining preparation, also may be discharged to natural streams.

Alberta Environment regulates water withdrawals and effluent discharges through licences and permits under the Water Resources Act and Clean Water Act, respectively. To comply with the regulatory requirements, the companies operating in the oil sands area maintain monitoring programs. In addition, Alberta Environment and the Alberta Oil Sands Environmental Research Program (AOSERP) (see Figure 1 for location of AOSERP study area) also conduct studies and monitoring programs in the area. Consequently, the existing data respecting water withdrawals and effluent discharges are dispersed among the various agencies and companies. In order to optimize the benefits of these data in future studies, particularly in view of the increased mining interests, the data should be compiled and stored in a data management system for easy access. The present study is intended to facilitate such a need and began on 1 April 1979 with the following objectives:

1. To compile all available chemical and physical characteristics, geographic locations, and amounts of significant water withdrawals from and contributions to the water system (both surface and groundwater) in the AOSERP study area; and
2. To review available systems and adopt an appropriate one for use by Alberta Environment to provide statistical summaries of wastewater quality/quantity information and of water use requirements.

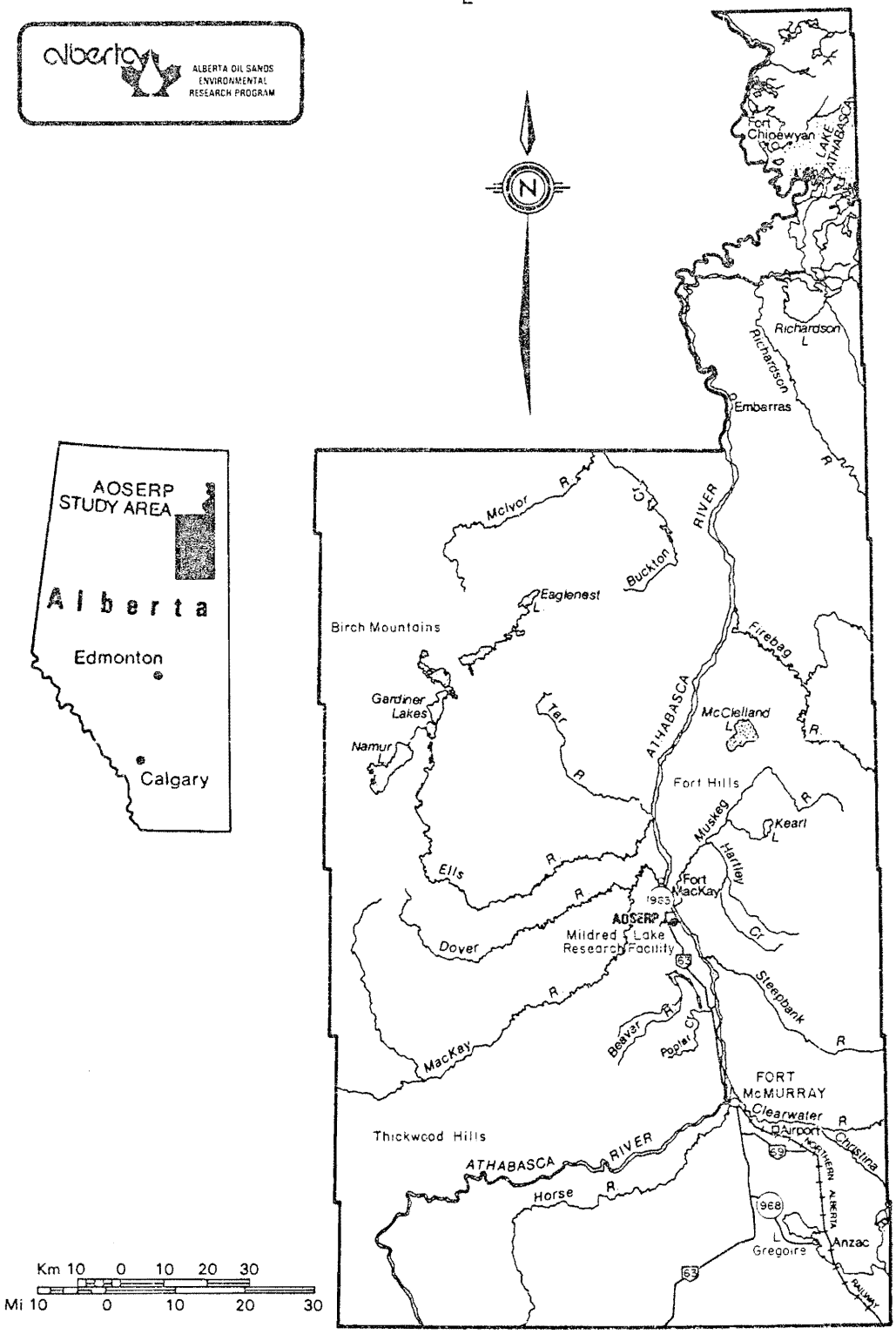


Figure 1. Location the AOSERP study area.

2. METHODS

At the outset of the study, the Energy Resources Conservation Board and the Water Rights Branch and Water Quality Branch of Alberta Environment identified the companies operating in the AOSERP study area. Subsequently, data were obtained from each of the companies and government agencies by the use of a form letter. The acquired data were then reported on summary tables; all data were reported as received.

The data management systems were evaluated through interviews and appraisals of written submissions obtained from data service bureaus. The appraisal evaluated the strengths and weaknesses of each data base system according to the following criteria:

1. Consistency and reliability of data storage;
2. Elimination of unplanned data redundancy;
3. Data program independence;
4. Methods of sharing stored data;
5. Speed of response to the user;
6. Ability to protect the data;
7. Efficiency and ease of use; and
8. Reliability and flexibility of report generation.

3. WATER USE AND WASTEWATER DISCHARGE

A total of 19 companies and government agencies were contacted requesting water use and wastewater discharge information; the names and the information received are given in Table 1. The geographic locations of water withdrawals and effluent discharges are shown in Figures 2 and 3. The detailed information associated with each of the operators in the Athabasca Oil Sands area are summarized in Tables 2 to 16.

Table 1. Summary of information sources.

Company or Government Agency Contacted	Person Contacted	Information Received
Alberta Environment Water Rights Branch	D. Cable V. Carlson E. Hoyes	Water withdrawal information for licenced withdrawals
Alberta Environment Water Quality Branch	L. Johnston A. Masuda	Industrial effluent information (quality)
Alberta Environment Municipal Engineering Branch	J. Milos	Municipal water withdrawal and effluent discharge information
Alsands Project Group	M. Wopnford	Water withdrawal and effluent discharge for Shell
Amoco Canada Petroleum Ltd.	R. Findlay	
Angus, R. Alberta Ltd.	D. Larson	
Athabasca Realty Co. Ltd.	R. Bibeau	
Energy Resources Conservation Board	B. Dunbar N. Lord L. Schmidt	List of projects in area
Great Canadian Oil Sands Ltd.[a]	W.L. Cary	
Gulf Canada Ltd.	R. Good R. Hodgkinson	
Northern Alberta Railways Co.	L. Halasa	
Petro Canada Exploration Inc.	J. Bhere	Water withdrawal information
Petrofina Canada Ltd.	L. McClennan	
RTR Oil Sands (Alberta) Ltd.	M. Southgate	
Redwood Ready Mix Ltd.	J. Hiley	
Syncrude Canada Ltd.	J. Retallack J. McKay	Water withdrawal and effluent discharge information
Texaco Canada Inc.	R. Cummen N. McFarlane	Water withdrawal and effluent discharge information
Union Oil Company of Canada Ltd.	P. Nicholls	Water withdrawal and effluent discharge information
University of Alberta	D. Flock	

[a] Now Suncor, Inc.

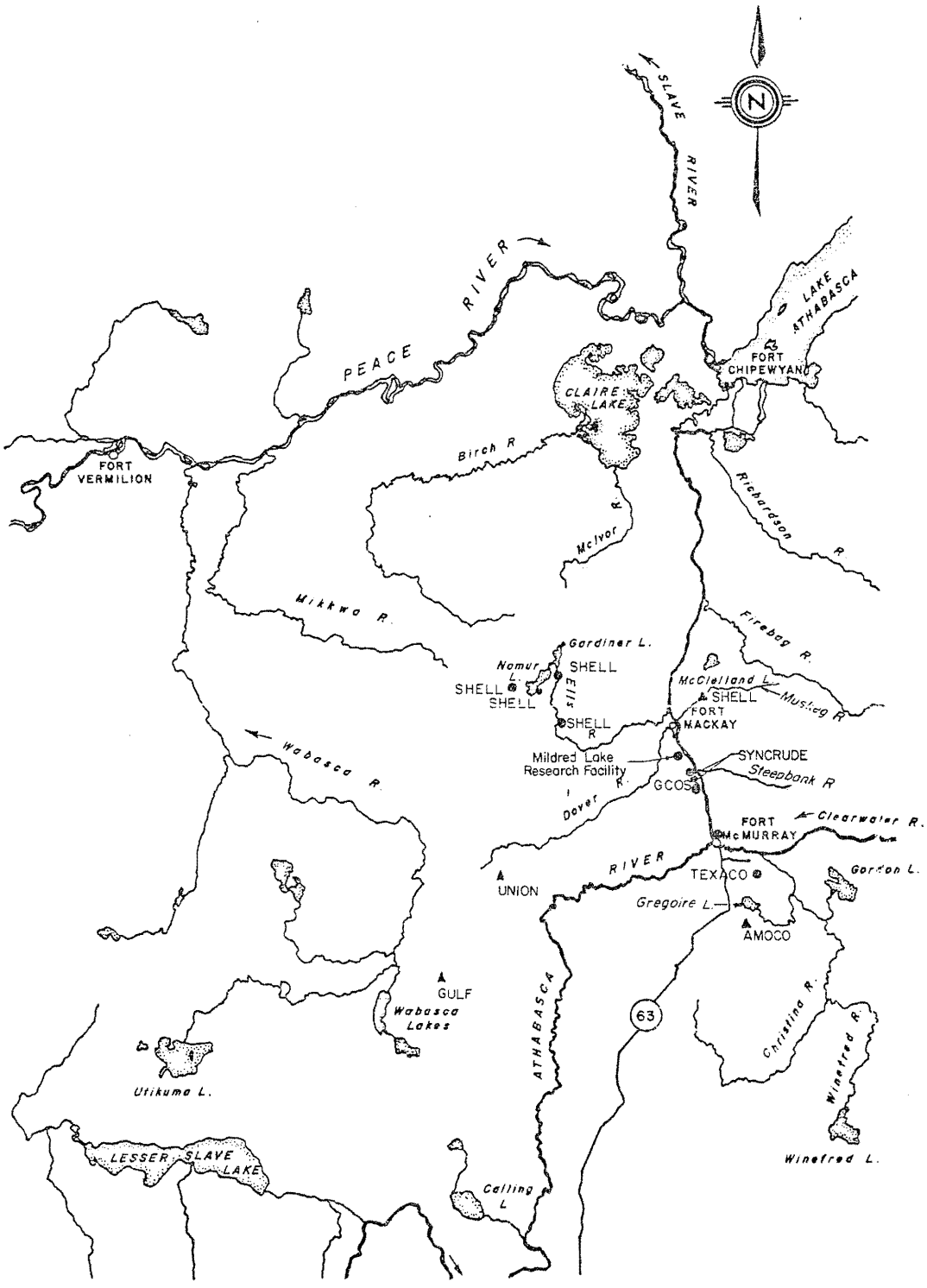
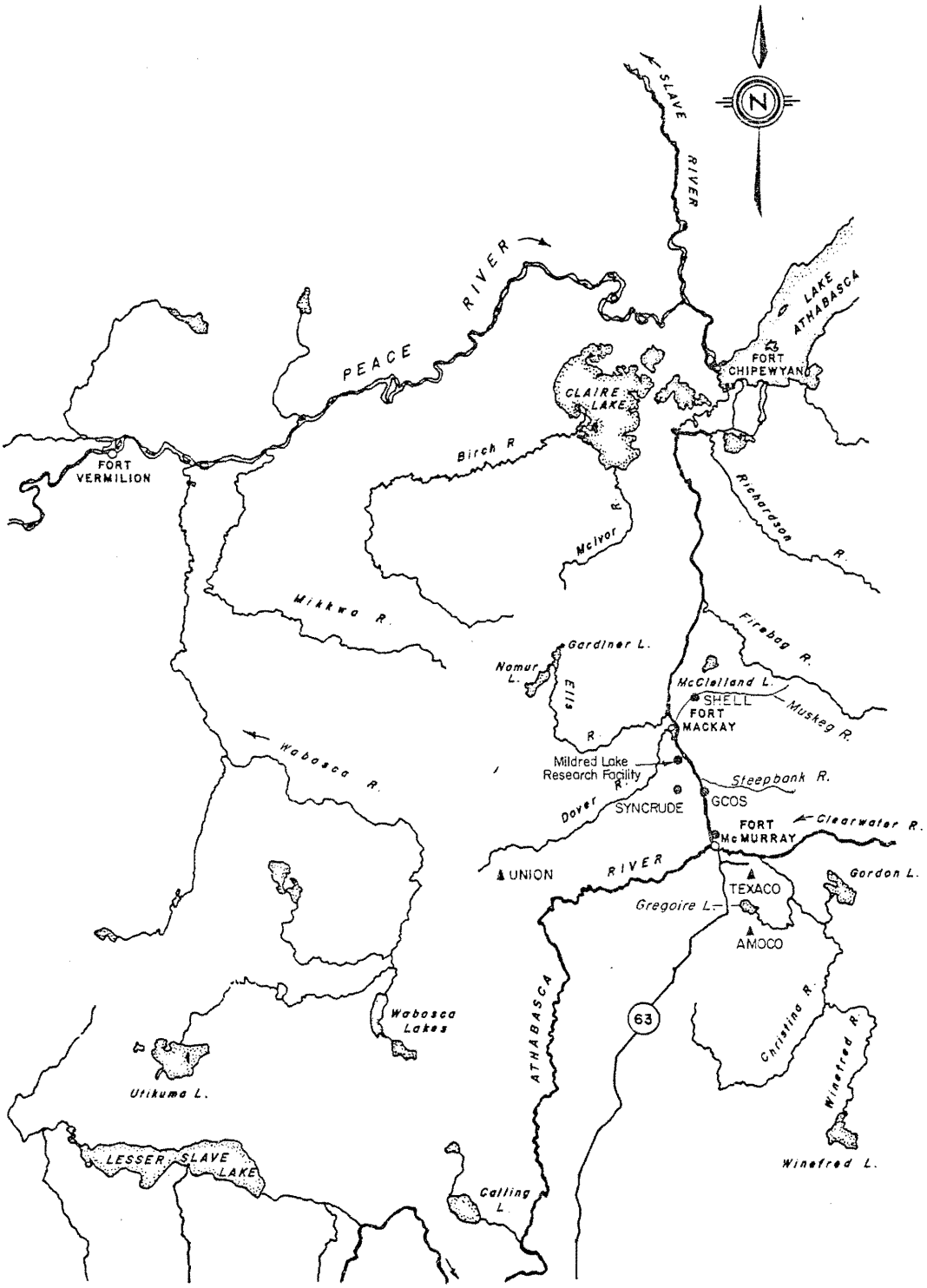


Figure 2. Locations of water withdrawals associated with oil sands developments in the AOSERP study area.



▲ deep well disposal

● to surface water

Figure 3. Locations of effluent discharges associated with oil sands developments in the AOSERP study area.

Table 2. Summary of water uses and effluent discharges in the AOSERP study area associated with Amoco Canada Petroleum Company Ltd.

Operator: Amoco Canada Petroleum Company Ltd.

Area: Gregoire Lake

Location (Legal): 27-85-8-W4

Water Withdrawal

Alberta Environment File No.: 12903; Industrial

Source (surface or groundwater): Groundwater (Grand Rapids Formation)

Source Location: LSD's 2, 3, 7-27-85-8-W4

Licenced Withdrawal (volume): 483 000 m^3/yr (7 wells)

Actual Withdrawal (seasonal volumes): N/D

Stream Flow Rate (max., mean, min.): N/A

Depth of Withdrawal (if groundwater source): 167.6 to 198.1 m below surface

End Use: Steam injection

Data Reference: Alberta Environment, Water Rights Branch; Alberta Research Council, Amoco Canada Petroleum Company Ltd.

Surface or Groundwater Quality: Groundwater Well No. 16

Well No. 16 water quality

Parameter[a]	5/12/76	6/12/76	7/12/76	8/12/76
pH	9.1 @ 70°C	9.0 @ 73°F	9.1 @ 74°F	8.9 @ 73°F
Sodium and Potassium	280	274	281	270
Calcium	5	5	6	5
Magnesium	1	2	1	2
Iron (total)	Trace	Trace	Trace	Trace
Sulfate	51	60	64	53
Chloride	41	41	39	41
Carbonate	19	29	29	14
Bicarbonate	588	549	561	576
Total Hardness (as $CaCO_3$)	6.6	20.7	19.9	20.7
Turbidity (as SiO_2)	6.0	6.8	7.5	4.5
Color Number	1000	1000	875	1000
Oil and Grease	56.4	60.8	45.2	47.6
Hydrogen Sulfide	Nil	Nil	Nil	Nil
Total Dissolved Solids - evaporated	875	870	915	835
- ignited	445	470	475	445
- calculated	985	960	981	961
Specific Gravity	1.001 @ 60°F	1.001 @ 60°F	1.001 @ 60°F	8.9 @ 73°F
Conductivity (micromho/cm)	1081 @ 25°C	1076 @ 25°C	1087 @ 25°C	1075 @ 25°C
Organic Matter	129	98	84	95
Saturation Index	+1.0 @ 72°F	+0.9 @ 73°C	+1.1 @ 74°F	+0.8 @ 73°F

continued ...

Table 2. Concluded

Effluent Discharge

Remarks: Date not released by Amoco

No discharge planned, it is to be re-injected

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[a] All values are reported as mg/L unless otherwise indicated
N/D - No data
N/A - Not applicable

Table 3. Summary of water uses and effluent discharges in the AOSERP study area associated with the Town of Fort McMurray.

Operator: Town of Fort McMurray

Area: N/A

Location (Legal): SE 20-89-9-W4

Water Withdrawal

Alberta Environment File No.: 12086

Source (surface or groundwater): Athabasca River

Source Location: SE 20-89-9-W4

Licenced Withdrawal (volume): 7 521 300 m^3/yr

Actual Withdrawal (seasonal volumes): 1977, 4 280 980 m^3; 1978, 4 542 370 m^3

Stream Flow Rate (max., mean, min.): As those reported in Table 4.

Depth of Withdrawal (if groundwater source): N/A

End Use (industrial, domestic or other): Municipal

Data Reference: Alberta Environment

Surface or Groundwater Water Quality: (before treatment)

Athabasca River water quality

Parameter[a]	2/1/79	1/2/79	1/3/79	2/4/79	1/5/79	4/6/79
pH	8.6	8.2	8.2	8.5	7.2	8.0
Iron (Ext)	0.31	0.23	0.24	0.07	1.96	0.08
Calcium	46	53	51	53	31	37
Total Hardness	173	190	179	174	107	127
Potassium	1.5	1.7	1.3	3.2	3.2	1.2
Nitrate + Nitrite -N	0.19	0.11	0.07	< 0.05	< 0.05	< 0.05
Flouride	0.13	0.32	0.17	0.87	0.20	1.14
Sulfate	37	41	35	75	22	109
Carbonate	< 5	N/D	N/D	< 5	N/D	N/D
Turbidity (NTU)	3	1.5	2	9	54	4
Conductivity (us/cm)	373	406	396	415	245	481
Total Dissolved Solids	213	235	213	258	134	292
Magnesium	14	14	12	10	7	8
Sodium	16	16	13	29	9	54
Silica	6.4	5.9	5.5	1.2	4.5	4.2
Nitrite -N	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	3	8	5	13	3	6
Bicarbonate	188	206	191	150	119	153
Alkalinity (Total)	157	169	157	125	98	126
Colour T1	N/D	N/D	99	99	97	99
Colour T2	N/D	N/D	97	98	94	99
Colour T3	N/D	N/D	95	96	89	97

continued ...

Table 3. Continued.

Athabasca River water quality

Parameter	15/3/79	20/3/79	2/4/79	16/4/79	Parameter	15/3/79	20/3/79	2/4/79	16/4/79
Total Coliform/100 mL	N/D	49	N/D	240	Turbidity (JTU)	2.4	N/D	2.8	N/D
Fecal Coliform/100 mL	N/D	33	N/D	33	Total Organic Carbon	4	N/D	9.5	N/D
Oil and Grease	0.40	N/D	0.50	N/D					

Effluent Discharge

Alberta Environment Licence No.: Letter of Permission 74-MP-142

Type of Discharge (municipal, industrial or depressurization): Municipal

Receiving Body: Athabasca River

Discharge Location: NE, NW 32-89-9-W4

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge: 8 832 m^3/day estimated by Alberta Environment

Pretreatment Provided: Aerobic lagoons

Data Reference: Alberta Environment; Stanley Associates Engineering Ltd.

Effluent Quality (final):

Final sewage effluent quality

Parameter[a]	22/6/77	26/7/79	27/7/79	Parameter[a]	22/6/77	26/7/79	27/7/79
pH	7.6	6.8	6.5	Conductivity (us/cm)	1070	664	664
Calcium	88	41	41	Magnesium	31	12	12
Sodium	88	73	77	Potassium	9.2	5.5	5.3
Iron (Ext)	0.73	0.20	0.09	Silica	12.5	N/D	N/D
Nitrate + Nitrite -N	< 0.1	< 0.05	< 0.05	Nitrite -N	0.1	N/D	N/D
Chloride	25	27	27	Sulfate	166	118	124
Flouride	0.55	N/D	N/D	Bicarbonate	440	N/D	N/D
Chemical Oxygen Demand	147.2	106	47	Biochemical Oxygen Demand	36.0	33	8.0
Oil and Grease	4.7	0.3	1.0	Total Residue	706	N/D	N/D
Total Filterable Residue Fixed	494	N/D	N/D	Non-Filterable Residue	62	12	16
Non-Filterable Residue Fixed	14	N/D	N/D	Ammonia -N	18.10	8.23	9.64
Phenols	0.051	0.013	0.014	Surfactants	3.50	0.73	0.71
Total Phosphorus (as P)	4.87	0.27	0.28	Nitrogen	20.66	N/D	N/D
Mercury (Total)	< 0.0001	N/D	N/D	Cobalt (Ext)	< 0.001	N/D	N/D
Copper (Ext)	< 0.001	N/D	N/D	Manganese (Ext)	0.240	N/D	N/D
Nickel (Ext)	< 0.003	N/D	N/D	Cadmium (Ext)	< 0.001	N/D	N/D
Chromium (Ext)	0.002	N/D	N/D	Lead (Ext)	< 0.003	N/D	N/D
Zinc (Ext)	0.008	N/D	N/D	Silver (Ext)	< 0.001	N/D	N/D
Molybdenum (Ext)	0.001	N/D	N/D	Total Hardness	346	N/D	N/D
Total Organic Carbon	N/D	4	4	Total Dissolved Solids	624	512	496
Total Inorganic Carbon	N/D	51	54	Alkalinity (Total)	361	145	131

Continued ...

Table 3. Concluded.

Final sewage effluent quality

Parameter	17/3/79	Parameter	22/6/77
2.5 day Biochemical Oxygen Demand	150	2.5 day Biochemical Oxygen Demand	75
at 35°C Suspended Solids	170	at 35°C Suspended Solids	40

Town of Fort McMurray sewage treatment efficiency

BOD (mg/L)	25/07/79	26/07/79	Average
- Raw	105	111	108
- Final	33	8	21
- % Removal	69%	93%	81%
Suspended Solids (mg/L)			
- Raw	328	216	272
- Final	12	16	14
- % Removal	96%	93%	95%
COD (mg/L)			
- Raw	192	247	220
- Final	106	47	77
- % Removal	45%	81%	63%

Loading to the Athabasca River

BOD - 185 kg/day
Suspended Solids - 124 kg/day
COD - 680 kg/day

[a] All values are reported in mg/L unless otherwise indicated
N/D - No Data
N/A - Not Applicable
< - Less than
(Ext) - Extractable

Table 4. Summary of water uses and effluent discharges in the AOSERP study area associated with Great Canadian Oil Sands Ltd.

Operator: Great Canadian Oil Sands Ltd. (GCOS) (Suncor, as of August 79)

Area: Mildred Lake

Location (Legal): Leases 83 + 86 (92-10-W4)

Water Withdrawal

Alberta Environment File No.: 11403

Source (surface or groundwater): Athabasca River

Source Location: 24-92-10-W4, SE and NE

Licenced Withdrawal (volume): 30 825 000 m^3/yr

Actual Withdrawal (seasonal volumes): 77 126 m^3/day

Stream Flow Rate (max., mean, min.):

Annual stream flow - Athabasca River below Fort McMurray - Station 070A001

Year	Max. (cms)	Mean (cms)	Min. (cms)
1958	2376	566	131
1959	1147	N/D	107
1960	4163	745	138
1961	1844	513	130
1962	2093	750	118
1963	2328	N/D	N/D
1964	1631	N/D	N/D
1965	3852	884	164
1966	2005	700	179
1967	1798	578	118
1968	1476	484	108
1969	2781	N/D	108
1970	3852	646	104
1971	4701	793	138
1972	3625	731	147
1973	2509	742	159
1974	2974	864	173
1975	2458	683	187
1976	2075	680	130
1977	2804	767	144

Depth of Withdrawal (if groundwater source) N/A

End Use (industrial, domestic or other): Industrial

Data Reference: Alberta Environment, Water Rights Branch, Water Quality Branch

continued ...

Table 4. Continued.

Surface Water Quality:

Athabasca River Water Quality - Above G.C.O.S. Plant (12/2/76)

Parameter[a]	Left Bank	Centre	Right Bank	Parameter[a]	Left Bank	Centre	Right Bank
Temperature(^{o}C)Field	2.0	0	1.5	Arsenic	< 0.0005	< 0.0005	< 0.0005
pH - Field	7.2	7.2	6.9	Boron	0.11	0.10	0.10
Conductivity (us/cm)	342	320	322	Beryllium	< 0.005	< 0.005	< 0.005
Temperature (^{o}C)	20.2	21.3	20.0	Chromium	< 0.015	< 0.015	< 0.015
pH	7.6	7.6	7.7	Copper	0.007	0.007	0.008
Turbidity (J.T.U.)	3.8	6.1	3.8	Lead	< 0.004	< 0.004	< 0.004
Non-Filterable Residue	5	7	7	Mercury (µg/L)	< 0.05	< 0.05	< 0.05
Fixed-Non-Filterable Residue	5	6	6	Nickel	< 0.002	< 0.002	< 0.002
Color	10	20	20	Silver	< 0.004	< 0.004	< 0.004
Total Dissolved Nitrogen	0.47	0.52	0.45	Vanadium	< 0.001	< 0.001	< 0.001
Total Phosphorus	0.025	0.017	0.02	Alkalinity (Phenol) ($CaCO_3$)	0.0	0.0	0.0
Dissolved Inorganic Carbon	30	30	30	Alkalinity (Total) ($CaCO_3$)	120	126	131
Dissolved Organic Carbon	9	10	11	Hardness Total	141	149	153
Total Inorganic Carbon	30	30	31	Calcium (Diss)	38.6	40.9	42.1
Total Organic Carbon	9	10	11	Sulphate (Diss)	25	28	29
Humic Acid	1	< 1	< 1	Sodium (Diss)	18.1	15.5	15.5
Fulvic Acid	9	10	< 1	Potassium (Diss)	1.8	1.7	2.0
Phenols	0.007	0.005	< 0.005	Chloride (Diss)	16.0	10.0	10.0
Aromatic Hydrocarbons	N/D	< 1	N/D	Silica Reactive	7.4	6.0	6.2
N-Alkanes	N/D	< 1	N/D	Flouride (Diss)	0.05	0.05	0.05
Oil and Grease	N/D	< 1	N/D	Nitrate + Nitrite -N	0.14	0.13	0.16
Aluminum	0.040	0.043	0.055	Magnesium (Diss)	10.8	11.4	11.6
Antimony	< 0.010	< 0.010	< 0.010	Hydroxide (Calcd)	0	0	0
Barium	0.05	0.05	0.06	Carbonate (Calcd)	0	0	0
Cadmium	< 0.001	< 0.001	< 0.001	Bicarbonate (Calcd)	146.3	153.6	159.7
Cobalt	< 0.002	< 0.002	< 0.002	Total Dissolved Solids (Calcd)	190.46	189.77	195.8
Iron	0.40	0.36	0.32	Sum Cations (Calcd)(Me/L)	3.6508	3.695	3.7826
Manganese	0.017	0.011	0.015	Sum Anions (Calcd) (Me/L)	3.382	3.3944	3.546
Molybdenum	< 0.10	< 0.10	< 0.10	Difference (Calcd) (%)	3.82	4.24	3.67
Selenium	< 0.0005	< 0.0005	< 0.0005	Saturation Index (Langelier's) (Calcd)	-0.26	-0.18	-0.09
Strontium	0.30	0.28	0.27	Stability Index (Ryznar's) (Calcd)	8.12	7.97	7.89
Zinc	< 0.001	0.003	< 0.001	Non Carbonate Hardness ($CaCO_3$) (Calcd)	21	23	22
Carbon Dioxide Free (Calcd)	5.85	6.14	5.07				

Table 4. Continued.

Surface Water Quality:

Athabasca River water quality

Parameter[a]	26/6/78	28/6/78	Parameter[a]	2/6/678	28/6/78
pH	7.3	7.6	Total Organic Carbon	25	15
Conductivity (us/cm)	210	210	Total Carbon	34	N/D
Temperature (^{0}C)	17.5	18.5	Total Inorganic Carbon	23	N/D
Bicarbonate	111	108	Oil and Grease	N/D	< 1.0
Calcium	28	27	Hydrocarbon	< 0.001	< 0.001
Magnesium	7	7	Surfactants	0.08	0.12
Sodium	8	5	Phenols	0.002	< 0.001
Potassium	1.0	0.8	Cyanide	< 0.002	< 0.002
Chloride	4	2	Chromium (Ext)	N/D	< 0.002
Sulfate	14	13	Mercury (T)	< 0.0001	< 0.0001
Fluoride	0.1	0.07	Sulfide	< 0.02	< 0.02
Iron (Ext)	1.01	1.13	Aluminum (Ext)	1.050	0.810
Silica	5.4	4.9	Arsenic (T)	0.0036	0.0034
Total Hardness	100	96	Cadmium (Ext)	< 0.001	< 0.001
Alkalinity (T)	91	89	Chromium (Ext)	0.004	0.002
Total Kjeldahl Nitrogen -N	0.58	0.40	Cobalt (Ext)	0.003	< 0.001
Ammonia -N	< 0.05	< 0.05	Copper (Ext)	0.007	0.023
Nitrate + Nitrite -N	< 0.53	< 0.35	Lead (Ext)	< 0.003	< 0.003
Nitrite -N	0.07	< 0.05	Manganese (Ext)	0.168	0.145
Nitrate -N	< 0.05	< 0.05	Molybdenum (Ext)	< 0.001	< 0.001
Total Organic Carbon	< 0.07	< 0.05	Nickel (Ext)	0.002	0.002
Phosphorus (T) (as P)	0.48	0.08	Selenium (T)	0.0004	0.0005
Turbidity (JTU)	86	N/D	Silver (Ext)	< 0.001	< 0.001
Total Residue	338	338	Vanadium (Ext)	0.004	0.004
Non-Filterable Residue	230	200	Zinc (Ext)	0.016	0.025
Total Dissolved Solids	117	107	Boron (Ext)	0.001	0.001
Odour (Unit)	1	1	Barium (Ext)	0.4352	0.3633
Chemical Oxygen Demand	25	14	Beryllium (Ext)	1.050	0.810

Remarks: GCOS has applied to increase licence to 59 184 000 m^3/yr

Effluent Discharge

Alberta Environment Licence No.: 78-WL-080

Type of Discharge (municipal, industrial or depressurization): Industrial effluent

Receiving Body: Athabasca River

continued ...

Table 4. Continued.

Discharge Location: SE 24-92-10-W4

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge: 62 320 m^3/day

Pretreatment Provided: Facilities include API separators, retention pond, storage pond, flare pond

Data Reference: Alberta Environment, Pollution Control Division, Water Quality Control Branch

Effluent Quality (final):

Final industrial effluent quality

Parameter[a]	16/12/76	21/6/77	21-22/ 6/77	22/6/77	22-23/ 6/77	23/6/77	23-24/ 6/77	24/6/77	9/8/77	21/9/77	3/10/77	21/9/77
pH	8.1	9.0	9.0	9.3	8.5	8.8	8.5	8.8	8.9	7.9	8.3	7.6
Conductivity(µs/cm)	700	635	665	700	800	710	610	600	540	440	450	600
Bicarbonate	223	8.0	13	17	167	27	14	17	7	139	150	163
Calcium	41	38	48	46	49	48	47	38	122	38	39	39
Magnesium	13	10	11	11	10	10	10	10	36	12	12	12
Sodium	87	51	51	52	50	50	51	50	13	37	34	73
Potassium	3.4	2.8	2.7	2.5	2.3	2.5	2.5	2.4	57	1.7	2.2	2.2
Chloride	90	58	56	57	58	57	60	57	1.8	42	31	81
Sulfate	63	174	183	187	173	172	152	150	69	49	51	53
Fluoride	0.18	0.12	0.08	0.08	0.10	0.08	0.10	0.80	53	0.11	0.13	0.11
Iron (Ext)	0.37	0.48	0.44	0.43	0.05	0.31	0.30	0.31	0.12	0.25	0.05	0.51
Silica	N/D	4.7	4.4	4.3	2.5	3.9	3.6	3.6	0.52	5.4	5.6	5.8
Hardness (Total)	155	135	165	160	162	162	158	135	144	142	144	146
Alkalinity (Total)	183	6.0	11	14	137	22	12	55	112	114	123	134
Total Kjeldahl Nitrogen -N	N/D	50.08	51.16	54.25	59.10	56.31	50.27	50.18	7.64	9.60	3.03	3.67
Ammonia -N	1.12	43.93	44.26	47.83	55.80	54.50	48.17	48.78	1.96	0.77	1.32	2.96
Total Organic Nitrogen -N	N/D	6.15	6.90	6.42	3.30	1.81	2.10	1.40	5.68	8.83	1.71	0.71
Nitrate + Nitrite -N	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.013	< 0.1	< 0.1
Nitrite -N	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	N/D	< 0.1	< 0.1
Nitrate	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	N/D	< 0.1	< 0.1
Phosphorus (Total) (as P)	N/D	0.33	0.34	0.32	0.27	0.27	0.25	0.39	N/D	0.25	0.21	0.22
Turbidity (JTU)	N/D	N/D	N/D	N/D	N/D	N/D	8	N/D	N/D	N/D	N/D	N/D
Total Residue	454	462	428	446	410	424	434	408	334	N/D	328	376
Non-Filterable Residue	18	42	37	41	32	28	N/D	27	41	N/D	58	21
Total Dissolved Solids	408	338	359	364	425	353	330	316	298	248	243	341
Odour (Unit)	10	100	100	1	N/D	N/D	N/D	N/D	10	N/D	1	1
Biochemical Oxygen Demand	62.5	50	67.5	93.3	43.3	69	32.5	64	12	N/D	5	22
Chemical Oxygen Demand	155.5	122.9	130.6	165.6	192	126	128.6	121	63.5	39.5	49	73.9
Total Organic Carbon	70	30	36	38	32	32	30	30	22	22	26	33
Total Carbon	98	57	63	60	60	57	58	55	42	45	47	61
Total Inorganic Carbon	28	27	27	22	28	25	28	25	20	24	21	28
(T1, T2, T3)	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	97/95/86	N/D	N/D
71/72/73 Color												
Oil and Grease	9.5	4.8	< 1.0	4.7	13.6	7.1	13.6	6.9	6.3	< 1.0	2.7	7.7
Hydrocarbon	2.218	< 0.001	0.074	0.115	0.130	0.010	0.130	< 0.001	N/D	N/D	N/D	0.137
Surfactants	0.54	0.85	0.83	1.0	0.74	0.70	0.70	0.54	0.42	0.20	0.05	0.35
Phenols	0.050	0.720	0.285	0.925	0.370	0.700	0.170	0.625	0.013	0.012	0.021	0.021
Pesticides	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.14	N/D	N/D	N/D

Continued

Table 4. Continued.

Parameter[a]	16/12/76	21/6/77	21-22/ 6/77	22/6/77	22-23/ 6/77	23/6/77	23-24/ 6/77	24/6/77	9/8/77	21/9/77	3/10/77	15/11/77
Chlorine	0.12	N/D		N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Cyanide	0.06	0.054	N/D	0.032	N/D	0.017	N/D	0.023	0.056	N/D	0.164	0.010
Chromium	< 0.002	0.008	0.008	0.013	0.006	0.019	0.007	0.008	0.002	0.002	0.006	0.005
Mercury (Total)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0005	0.0007	< 0.0001	< 0.0001	< 0.0001
Sulfide	< 0.02	21.38	< 0.02	12.0	< 0.02	6.70	< 0.02	30.0	< 0.02	N/D	< 0.02	< 0.02
Aluminum (Ext)	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.122	N/D	N/D
Arsenic (Total)	0.0041	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.0027	0.0020	0.0029
Cadmium (Ext)	< 0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chromium (Ext)	0.005	0.003	N/D	0.004	N/D	0.006	N/D	0.003	0.005	0.006	0.004	0.007
Cobalt (Ext)	0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper (Ext)	0.004	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	0.016	0.004	0.002	0.006
Lead (Ext)	< 0.003	< 0.003	N/D	< 0.003	N/D	< 0.003	N/D	0.004	< 0.003	< 0.003	< 0.003	< 0.003
Manganese (Ext)	0.031	0.030	N/D	0.038	N/D	0.032	N/D	0.030	0.043	0.050	< 0.008	0.042
Molybdenum (Ext)	0.270	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.127	0.137	0.110	0.191
Nickel (Ext)	0.022	0.019	N/D	0.020	N/D	0.017	N/D	0.017	0.020	0.030	0.003	0.038
Selenium (Total)	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.0013	N/D	0.0004
Silver (Ext)	< 0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium (Ext)	N/D	N/D	N/D	0.34	N/D	N/D	N/D	N/D	0.20	0.090	N/D	N/D
Zinc (Ext)	0.048	0.060	N/D	0.014	N/D	0.036	N/D	0.017	0.044	0.135	< 0.001	0.024

Parameter[a]	11/4/78	8/5/78	26/6/78	26-27/ 6/78	27/6/78	27-28/ 6/78	28/6/77	28-29/ 6/78	29/6/78	20/7/78	22/8/78	2/11/78	11/12/78
pH	7.6	7.8	7.5	7.4	7.4	7.0	6.9	7.3	7.4	7.6	7.6	7.9	8.1
Conductivity (us/cm)	783	555	511	530	N/D	538	538	537	608	360	560	620	711
Bicarbonate	180	148	107	104	106	98	99	N/D	103	125	127	178	200
Calcium	46	40	34	35	36	34	35	N/D	37	33	42	43	51
Magnesium	13	11	10	10	10	9	10	N/D	10	9	12	15	13
Sodium	70	51	54	58	58	56	54	N/D	67	26	50	65	71
Potassium	3.5	4.2	2.1	2.3	2.3	1.8	2.0	N/D	2.1	1.4	1.8	2.3	2.7
Chloride	89	51	62	68	67	62	60	N/D	74	29	62	78	77
Sulfate	81	69	65	68	70	71	67	N/D	86	36	82	63	75
Fluoride	0.13	0.11	0.11	0.12	0.09	0.13	0.09	N/D	0.09	0.09	0.18	0.14	0.18
Iron (Ext)	0.42	0.23	0.57	0.54	0.52	0.49	0.39	N/D	0.56	1.06	0.23	0.26	0.37
Silica	5.8	5.4	5.9	5.9	5.7	5.2	5.4	N/D	5.2	5.7	5.5	5.0	6.4
Total Hardness	169	144	125	129	129	122	130	N/D	131	119	152	168	182
Alkalinity (Total)	148	122	88	68	87	81	81	N/D	85	103	104	146	164
Total Kjeldahl Nitrogen -N	10.53	4.68	4.29	3.95	3.42	2.29	2.05	2.66	3.14	1.90	1.97	3.28	8.52
Ammonia -N	9.72	4.45	0.31	0.16	0.18	0.09	0.26	0.66	1.20	1.08	0.50	1.47	4.96
Total Organic Nitrogen	0.81	0.23	3.98	3.79	3.24	2.20	1.79	2.00	1.94	0.82	1.47	3.28	3.56

Continued ...

Table 4. Concluded.

Parameter[a]	11/4/78	8/5/78	26/6/78	26-27/ 6/78	27/6/78	27-28/ 6/78	28/6/78	28-29/ 6/78	29/6/78	20/7/78	22/8/78	2/11/78	11/12/78
Nitrate + Nitrite -N	< 0.10	< 0.05	0.45	0.41	0.45	0.48	0.48	N/D	0.32	0.15	0.21	0.25	0.18
Nitrite -N	0.10	< 0.05	0.37	0.34	0.34	0.31	0.22	N/D	0.22	< 0.05	0.09	0.18	< 0.05
Nitrate -N	0.10	< 0.05	0.08	0.07	0.11	0.17	0.26	N/D	0.10	< 0.15	0.12	0.07	< 0.13
Phosphorus (Total) (as P)	0.26	0.21	0.60	0.73	0.36	0.54	0.34	0.33	0.22	0.19	0.19	0.16	0.22
Turbidity (JTU)	N/D	7	N/D	N/D	N/D	N/D	N/D	14	N/D	N/D	N/D	N/D	N/D
Total Residue	464	380	326	332	352	368	370	420	362	396	1110	459	293
Non-Filterable Residue	199	N/D	38	29	28	25	24	N/D	22	154	25	29	23
Total Dissolved Solids)	392	300	281	294	297	285	279	N/D	327	196	312	356	388
Odour (Unit)	10	10	1.0	1.0	10	10	10	N/D	10	100	1	N/D	1000
Biochemical Oxygen Demand	10.5	5.8	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Chemical Oxygen Demand	66.7	30.3	57	73	53	46	50	53	39	30	43	56	81
Total Organic Carbon	28	13	19	22	18	20	16	18	21	13	170	15	22
Total Carbon	60	46	42	43	N/D	N/D	N/D	N/D	N/D	43	N/D	50	N/D
Total Inorganic Carbon	32	33	23	21	21	N/D	N/D	N/D	N/D	30	N/D	35	N/D
Oil and Grease	2.6	1.3	N/D	N/D	N/D	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Hydrocarbon	0.004	< 0.001	< 0.001	0.026	< 0.001	0.009	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	0.633
Surfactants	N/D	N/D	0.59	0.64	0.65	0.50	0.50	N/D	0.61	0.36	0.47	0.56	0.83
Phenols	0.033	0.016	0.010	0.012	0.012	0.013	0.005	0.010	0.028	0.030	0.008	0.010	0.173
Chlorine	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Cyanide	0.100	0.019	0.003	N/D	0.009	N/D	0.007	N/D	0.008	N/D	N/D	N/D	N/D
Chromium (Cr^{+6}) (Ext)	0.005	< 0.002	N/D	0.021	N/D	< 0.002	< 0.002	0.004	< 0.002	< 0.002	< 0.002	N/D	N/D
Mercury (Total)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sulfide	N/D	N/D	< 0.02	< 0.02	< 0.02	N/D	< 0.02	N/D	< 0.02	< 0.02	< 0.02	< 0.02	N/D
Aluminum (Ext)	0.137	0.410	0.450	N/D	N/D	N/D	N/D	N/D	N/D	1.490	0.140	0.260	0.310
Arsenic (Total)	0.0048	0.0062	0.0036	0.0043	0.0043	N/D	0.0034	N/D	0.0049	0.0043	0.0022	0.0046	0.0062
Cadmium (Ext)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chromium (Ext)	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	N/D	0.006	N/D	< 0.002	< 0.002	< 0.002	< 0.001	< 0.001
Cobalt (Ext)	0.001	0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper (Ext)	0.004	0.003	0.010	N/D	0.006	N/D	0.011	N/D	0.006	0.022	< 0.001	0.002	0.006
Lead (Ext)	< 0.003	< 0.003	< 0.003	N/D	< 0.003	N/D	< 0.003	N/D	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Manganese (Ext)	0.040	0.038	0.035	N/D	0.030	N/D	0.038	N/D	0.035	0.155	0.120	0.040	0.036
Molybdenum (Ext)	0.160	0.410	0.234	N/D	0.235	N/D	0.230	N/D	0.256	0.027	0.162	0.188	0.295
Nickel (Ext)	0.031	0.009	0.014	N/D	0.011	N/D	0.018	N/D	0.016	0.013	0.017	0.032	0.048
Selenium (Total)	0.0007	< 0.0002	0.0018	N/D	0.0015	N/D	0.0006	N/D	0.0002	0.0008	0.0007	0.0012	0.0025
Silver (Ext)	< 0.001	< 0.001	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium (Ext)	0.152	0.275	0.228	N/D	0.234	N/D	0.202	N/D	0.232	0.066	0.150	0.510	0.435
Zinc (Ext)	0.020	0.004	< 0.001	N/D	< 0.001	N/D	0.002	N/D	< 0.001	0.025	0.030	0.004	0.005
Barium (Ext)	N/D	N/D	0.4821	N/D	0.3890	N/D	0.3332	N/D	N/D	N/D	N/D	N/D	N/D
Boron (Ext)	N/D	N/D	< 0.001	N/D	< 0.001	N/D	< 0.001	N/D	N/D	N/D	N/D	N/D	N/D

[a] All values are actual and report in mg/L unless otherwise indicated
(Ext) - Extractable
N/A - Not applicable
N/D - No data
< - Less than
(Calcd) - Calculated

Table 5. Summary of water uses and effluent discharges in the AOSERP study area associated with Great Canadian Oil Sands Ltd.

Operator: Great Canadian Oil Sands Ltd.

Area: Mildred Lake

Location (Legal): Leases 83 + 86 (92-10-W4)

Effluent Discharge

Alberta Environment Licence No.: 78-WL-080

Type of Discharge (municipal, industrial or depressurization): Municipal effluent

Receiving Body: Athabasca River

Discharge Location: SE 24-92-10-W4

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge (seasonal volumes): 205 m^3/day

Pretreatment Provided: Five months retention in summer, seven months retention in winter

Data Reference: Alberta Environment, Pollution Control Division, Water Quality Control Board

Effluent Quality (final):

Final municipal effluent quality

Parameter	26/6/78	28/6/78	Parameter	26/6/78	28/6/78
pH	7.5	7.4	Potassium	6.3	6.1
Conductivity (µs/cm)	503	526	Chloride	22	21
Temperature (°C)	19	20	Sulfate	29	31
Bicarbonate	232	239	Fluoride	0.11	0.12
Calcium	51	49	Iron (Ext)	0.42	0.45
Magnesium	13	13	Silica	8.0	7.6
Sodium	30	30	Total Hardness	182	174
Alkalinity (Total)	190	196	Chromium (Cr^{+6})	N/D	0.002
Total Kjeldahl Nitrogen -N	8.18	5.29	Mercury (Total)	< 0.0001	< 0.0001
Ammonia -N	4.48	3.42	Sulfide	< 0.02	< 0.02
Total Organic Nitrogen	3.7	1.87	Aluminum (Ext)	< 0.020	0.030
Nitrate + Nitrite -N	0.11	0.20	Arsenic (Total)	0.0021	0.0017
Nitrite -N	< 0.05	< 0.05	Cadmium (Ext)	< 0.001	< 0.001
Nitrate -N	< 0.11	2.85	Chromium (Ext)	< 0.002	< 0.002
Phosphorus (Total) (as P)	3.49	202	Cobalt (Ext)	< 0.001	0.002
Total Residue	294	19	Copper (Ext)	0.007	0.003
Non-Filterable Residue	17	268	Lead (Ext)	< 0.003	< 0.003
Total Dissolved Solids	265	10	Manganese (Ext)	0.260	0.262
Odour (Unit)	1	57	Molybdenum (Ext)	0.003	0.002
Chemical Oxygen Demand	69	27	Nickel (Ext)	0.002	0.006
Total Organic Carbon	28	N/D	Selenium (Total)	0.0003	< 0.0002
Total Carbon	77	N/D	Silver (Ext)	< 0.001	< 0.001
Total Inorganic Carbon	49	N/D	Vanadium (Ext)	0.004	0.003
Oil and Grease	N/D	< 1.0	Zinc (Ext)	0.015	0.028
Hydrocarbon	< 0.001	< 0.001	Boron (Diss.)	0.2231	0.001
Surfactants	0.86	0.51	Barium (Total)	0.2323	N/D
Phenols	0.013	0.002	Beryllium (Ext)	N/D	< 0.001
Cyanide	0.007	0.005			

Continued ...

Table 5. Concluded.

[a] All values are actual and reported as mg/L unless otherwise indicated
< - Less than
(Ext) - Extractable
(Diss) - Dissolved
N/A - Not Applicable
N/D - No Data

Table 6. Summary of water uses and effluent discharges in the AOSERP study area associated with Gulf Oil Canada Ltd.

Operator: Gulf Oil Canada Limited

Area: Wood River

Location (Legal): 6-83-22-W4

Water Withdrawal

Alberta Environment File No.: 16917

Source (surface or groundwater): Groundwater

Source Location: 5-6-83-22-W4

Licenced Withdrawal (volume): No licence

Actual Withdrawal (seasonal volumes): N/D

Stream Flow Rate (max., mean, min.): N/A

Depth of Withdrawal (if groundwater source): 76.5 m

End Use (industrial, domestic or other): Industrial

Data Reference: Alberta Research Council; Alberta Environment, Water Rights Branch

Surface or Groundwater Water Quality:

Well water (Wabasca) quality - Laboratory analysis conducted by Alberta Environment, Pollution Control Laboratory

Parameter[a]	17/2/75	Parameter[a]	17/2/75
pH	8.3	Total Dissolved Solids	1052
Calcium	93	Magnesium	32
Sodium	229	Potassium	6.0
Iron (Total)	2.4	Nitrate + Nitrite (as N)	<0.1
Nitrite (as N)	<0.1	Chloride	9
Sulfate	409	Fluoride	0.19
Bicarbonate	544	Total Hardness	363
Alkalinity (Total)	446		

Well water (Wabasca) - Laboratory analysis conducted by Dearborn Chemical Co. Limited.

Parameter[a]	March 1975	Parameter[a]	March 1975
pH	8.3	Alkalinity (Total)	490
Turbidity (JTU)	40 (filtered), 23 (shaken)	Sodium Chloride	6.4
Color	19	Iron Oxide	0.07 (filtered), 4.2 (shaken)
Biochemical Oxygen Demand	23 (filtered), 23 (shaken)	Silica (non-reactive)	10.5
Total Dissolved Solids	1359	Silica (reactive)	21.0 (filtered), 21.0 (shaken)
Specific Conductance (micromhos)	1650	Sodium Ion	230
Total Hardness	399 (filtered), 410 (shaken)	Carbonate Ion	6.6
Magnesium Hardness	270 (filtered), 280 (shaken)	Sulfate Ion	398
Alkalinity (Total)	129 (filtered), 130 (shaken)		

Table 6. Concluded.

Well water (Wabasca) quality - Laboratory analysis conducted by Chemical & Geological Laboratories Limited.

Parameter[a]	1975	Parameter[a]	1975
pH	8.0 @ 68°F	Total Hardness (as $CaCO_3$)	446
Sodium and Potassium	167	Suspended Solids	15.5
Calcium	116	Total Dissolved Solids - evaporated	1280
Magnesium	38	- ignited	940
Iron (Total)	4.8	- calculated	1186
Silica (Total)	22.0	Specific Gravity	1.001 @ 60°F
Sulfate	431	Conductivity (millimhos)	1.54 @ 25°C
Chloride	9	Saturation Index	+1.1 @ 68°F
Carbonate	Nil		
Bicarbonate	425		

Remarks: No licence issued; exploration permit cancelled.

Effluent Discharge

Remarks: No information was received from Gulf Oil Canada Limited.

[a] All values are reported in mg/L unless otherwise indicated
< - Less than
N/D - No data
N/A - Not applicable

Table 7. Summary of water uses and effluent discharge in the AOSERP study area associated with Petro-Canada Exploration Inc.

Operator: Petro-Canada Exploration Inc.
Area: Mildred Lake
Location (Legal): 34-92-10-W4

Water Withdrawal

Alberta Environment File No.: 18795
Source (surface or groundwater): Slough
Source Location: 9-34-92-10-W4
Licenced Withdrawal (volume): 18 495 m^3/yr
Actual Withdrawal: (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): N/A
Depth of Withdrawal (if groundwater source): N/A
End Use (industrial, domestic or other): Industrial
Data Reference: Alberta Environment, Water Rights Branch; Petro-Canada
Surface or Groundwater Water Quality: N/D
Remarks: Project will not start up until October 1979.

Effluent Discharge

Remarks: Petro-Canada Exploration Inc. intends using another company's disposal well after start up.

N/D - No data
N/A - Not applicable

Table 8. Summary of water uses and effluent discharges in the AOSERP study area associated with Petro-Canada Exploration Inc.

Operator: Petro-Canada Exploration Inc.
Area: Surmont
Location (Legal): 26-85-9-W4

Water Withdrawal

Alberta Environment File No.: N/A
Source (surface or groundwater): Groundwater
Source Location: 8-26-85-9-W4
Licenced Withdrawal (volume): Has not been licenced
Actual Withdrawal (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): N/A
Depth of Withdrawal (if groundwater source): 120 to 150 m
End Use (Industrial, domestic or other): Industrial
Data Reference: Petro-Canada Exploration Inc.
Surface or Groundwater Water Quality: N/D
Remarks: Are in the process of applying for licence.

Effluent Discharge

Remarks: No effluent discharge yet; will not start up until 1980.

N/D - No data
N/A - Not applicable

Table 9. Summary of water uses and effluent discharges in the AOSERP study area associated with Shell Canada Resources Ltd.

Operator: Shell Canada Resources Ltd.
Area: Gardiner Lake
Location (Legal): 9-98-16-W4

Water Withdrawal

Alberta Environment File No.: 11026
Source (surface or groundwater): Gardiner Lake
Source Location: NE 9-98-16-W4
Licenced Withdrawal (volume): N/D
Actual Withdrawal (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): N/D
Depth of Withdrawal (if groundwater source): N/A
End Use (industrial, domestic or other): Industrial
Data Reference: Alberta Environment; Shell
Surface or Groundwater Quality: N/D
Remarks: Licence has not been issued; water no longer being withdrawn.

Effluent Discharge

Remarks: No data available

N/D - No data
N/A - Not applicable

Table 10. Summary of water uses and effluent discharges in the AOSERP study area associated with Shell Canada Resources Ltd.

Operator: Shell Canada Resources Ltd.
Area: Lease 45, South of Namur Lake
Location (Legal): 33-96-17-W4

Water Withdrawal

Alberta Environment File No.: 11026
Source (surface or groundwater): Namur Lake
Source Location: NW 33-96-17-W4
Licenced Withdrawal (volume): N/D
Actual Withdrawal (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): N/D
Depth of Withdrawal (if groundwater source): N/A
End Use (industrial, domestic or other): Industrial
Data Reference: Alberta Environment; Shell
Surface or Groundwater Water Quality: N/D
Remarks: Licence has not been issued; water no longer being withdrawn.

Effluent Discharge

Remarks: No data available

N/D - No data
N/A - Not applicable

Table 11. Summary of water uses and effluent discharges in the AOSERP study area associated with Shell Canada Resources Ltd.

Operator: Shell Canada Resources Ltd.
Area: Lease 45, South of Namur Lake
Location (Legal): 31-96-18-W4

Water Withdrawal

Alberta Environment File No.: 11026
Source (surface or groundwater): Legend Lake
Source Location: NW 31-96-18-W4
Licenced Withdrawal (volume): N/D
Actual Withdrawal (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): N/D
Depth of Withdrawal (if groundwater source): N/A
End Use (industrial, domestic or other): Industrial
Data Reference: Alberta Environment; Shell
Surface or Groundwater Water Quality: N/D
Remarks: Licence has not been issued; water no longer being withdrawn

Effluent Discharge

Remarks: No data available

N/D - No data
N/A - Not applicable

Table 12. Summary of water uses and effluent discharges in the AOSERP study area associated with Shell Canada Resources Ltd.

Operator: Shell Canada Resources Ltd.
Area: Lease 53, South of Namur Lake
Location (Legal): 21-95-16-W4

Water Withdrawal

Alberta Environment File No. 11026
Source (surface or groundwater): Ells River
Source Location: SE 21-95-16-W4
Licenced Withdrawal (volume): N/D
Actual Withdrawal (seasonal volumes): N/D
Stream Flow Rate (max., mean, min.): 1976, 16.1, 3.5, 1.1; 1977, 9.2, 3.4, 0.2 cms
Depth of Withdrawal (if groundwater source): N/A
End Use (industrial, domestic or other): Industrial
Data Reference: Alberta Environment; Shell
Surface or Groundwater Water Quality: N/D
Remarks: Licence has not been issued; water is no longer being withdrawn

Effluent Discharge

Remarks: No data available.

N/D - No data
N/A - Not applicable

Table 13. Summary of water uses and effluent discharges in the AOSERP study area associated with Shell Canada Resources Ltd.

Operator: Shell Canada Resources Ltd.

Area: Lease 13 at Muskeg River

Location (Legal): 95-10-W4

Water Withdrawal

Alberta Environment File No.: 13973

Source (surface or groundwater): Groundwater

Source Location: 25, 30, 36-95-10-W4

Licenced Withdrawal (volume): Quantity applied for -- 1 233 000 m^3/yr

Actual Withdrawal (seasonal volumes): N/D

Stream Flow Rate (max., mean, min.): N/A

Depth of Withdrawal (if groundwater source): N/D

End Use (industrial, domestic or other): Industrial, depressurization

Data Reference: Alberta Environment, Water Rights Branch

Surface or Groundwater Water Quality: N/D

Remarks: An exploration permit for groundwater has been issued; licence has not been issued.

Effluent Discharge

Alberta Environment Licence No.: N/A

Type of Discharge (municipal, industrial or depressurization): depressurization (as accumulated in Shell test pit)

Receiving Body: Muskeg River

Discharge Location: Approximately 400 m upstream of Muskeg River and Hartley Creek confluence

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge (seasonal volumes): Approximately 4900 m^3/day

Pretreatment Provided: Setting pond

Data Reference: Alberta Environment, Water Quality Branch

Effluent Quality (final):

Depressurization efffluent quality

Parameters	28/7/76	3/9/76	30/9/76	14/10/76	29/6/77	14/9/77	21/6/78
pH	8.2	8.0	7.9	8.0	8.0	7.64	7.67
Conductivity (µs/cm)	2200	2950	4200	3700	2720	3790	3900
Carbonate	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonate	509.5	755.8	1066.6	1036.2	718.7	1195.1	1156.0
Hardness (Total)	202.9	205.0	232.4	241.5	206.6	277.4	169.0
Alkalinity (Total)	418.0	620.0	875.0	650.0	509.8	980.4	948.0
Calcium	12.0	28.5	37.0	39.0	27.5	57.5	10.000
Magnesium	42.0	32.5	34.0	35.0	33.5	32.5	35.00
Sodium	410.0	500.0	860.0	730.0	500.0	900.0	785.00
Potassium	13.5	14.5	15.0	14.0	18.2	23.8	13.00

Continued ...

Table 13. Concluded.

Parameters[a]	28/7/76	3/9/76	30/9/76	14/10/76	29/6/77	14/9/77	21/6/78
Chloride	330.0	460.0	825.0	710.0	430.0	805.0	750.00
Sulphate	71.0	57.4	58.0	86.0	73.0	65.0	70.00
Silica	7.5	6.6	6.7	7.0	5.2	6.0	5.00
Threshold Odor	8	4	64	4	32	64	128
Color	10	10	< 5	< 5	< 5	< 5	< 5
Tannin & Lignin	0.02	< 0.2	0.40	0.70	0.3	0.9	< 0.1
Total Filt. Residue	1752	1505	2405	2105	1640	2550	2574
Total Filt. Residue Fixed	1264	1390	2175	1875	1394	2260	2477
Total Non-Filt. Residue	12.4	23.2	24.0	38.0	14.4	19.0	6.8
Total Non-Filt. Residue Fixed	6.8	18.0	18.0	26.4	6.0	11.6	10.4
Turbidity	20.0	N/D	N/D	N/D	10.3	6.05	9.1
Surfactants	0.21	0.20	0.10	0.07	0.135	0.69	0.52
Humic Acids	< 12.0	< 11.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total Organic Carbon	20	32	50	40	17	45	22
Total Inorganic Carbon	150	120	250	220	59	205	173.5
Nitrate + Nitrite -N	0.01	< 0.01	< 0.01	< 0.01	0.013	0.007	0.010
Ammonia -N	0.19	0.94	2.20	1.80	0.39	1.85	2.450
Total Kjeldahl Nitrogen	1.40	5.50	4.85	2.68	0.80	2.63	2.31
Total Phosphorus (as P)	< 0.005	0.02	0.05	0.06	0.021	0.049	0.042
Ortho Phosphorus (as P)	< 0.005	< 0.01	0.03	0.02	0.006	0.039	0.037
Phenol	0.004	< 0.001	< 0.001	0.020	< 0.001	N/D	< 0.001
Oil and Grease	2.8	3.0	1.0	1.70	2.9	N/D	0.6
Sulphide	< 0.05	< 0.05	< 0.05	< 0.05	N/D	N/D	0.001
Cyanide	< 0.01	< 0.01	< 0.01	< 0.01	N/D	N/D	0.001
Chemical Oxygen Demand	36.6	111.0	59.8	234	121	124	128
Cadmium (Ext)	< 0.001	< 0.001	0.004	0.003	0.001	< 0.001	< 0.001
Chromium (Cr^{6})	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Copper (Ext)	0.002	0.004	0.010	0.012	0.002	0.005	< 0.001
Iron (Ext)	0.41	1.15	0.45	0.85	0.11	0.45	0.330
Lead (Ext)	0.008	0.012	0.031	0.031	0.002	< 0.002	< 0.002
Manganese (Ext)	0.04	0.162	0.193	0.238	0.043	0.135	0.360
Silver (Ext)	< 0.005	0.015	< 0.005	0.005	< 0.001	< 0.001	< 0.001
Zinc (Ext)	< 0.001	0.009	0.001	0.008	0.001	0.012	0.001
Vanadium (Ext)	0.01	< 0.001	0.001	0.002	< 0.001	< 0.001	< 0.001
Selenium (Total)	0.0027	< 0.0005	< 0.0005	< 0.0005	0.0008	0.0005	< 0.0002
Mercury (Total)	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0001	0.001	0.0002
Arsenic (Total)	0.005	0.010	0.010	0.005	0.0012	0.0007	0.0004
Nickel (Ext)	0.011	0.018	< 0.002	0.013	0.006	0.005	0.005
Aluminum (Ext)	0.20	0.36	0.33	0.50	0.06	0.33	0.14
Cobalt (Ext)	0.006	0.013	0.011	0.007	< 0.002	0.004	0.004
Boron (Ext)	0.92	0.95	0.20	0.88	1.42	2.1	1.50
Chlorophyll a	N/D	0.001	0.001	< 0.001	< 0.001	N/D	N/D
Titanium (Ext)	N/D	N/D	N/D	N/D	N/D	N/D	0.15

[a] All values are actual and reported as mg/L unless otherwise indicated
< - Less than
(Ext) - Extractable
N/D - No data
N/A - Not applicable

Table 14. Summary of water uses and effluent discharges in the AOSERP study area associated with Syncrude Canada Ltd.

Operator: Syncrude Canada Ltd.

Area: Mildred Lake

Location (Legal): Lease 17, Twps. 92, 93, Rge 10 - W4

Water Withdrawal

Alberta Environment File No.: 15974

Source (surface or groundwater): Surface water (Athabasca River)

Source Location: NW 35-92-10-W4

Licenced Withdrawal (volume): 1 200 000 m^3/yr

Actual Withdrawal (seasonal volumes): 1975, 220 000; 1976, 460 000; 1977, 430 000; 1978, 630 000 m^3/yr

Stream Flow Rate (max., mean, min.): As those reported in Table 4.

Depth of Withdrawal (if groundwater source): N/A

End Use (industrial, domestic or other): Municipal

Data Reference: Alberta Environment, Water Rights Branch; Syncrude

Surface or Groundwater Water Quality:

Athabasca River water quality

Parameter[a]	15/3/79	20/3/79	2/4/79	16/4/79
Oil and Grease	0.40	N/D	0.50	N/D
Turbidity (NTU)	2.4	N/D	2.8	N/D
Total Organic Carbon	4	N/D	9.5	N/D
Total Coliform /100 mL	N/D	Nil	N/D	240
Fecal Coliform /100 mL	N/D	Nil	N/D	33

Continued ...

Table 14. Continued.

Water Withdrawal

Alberta Environment File No.: 15607

Source (surface or groundwater): Athabasca River

Source Location: 23-92-10-W4

Licenced Withdrawal (volume): 132 000 000 m^3/yr

Actual Withdrawal (seasonal volumes): 1977, 13 000 000; 1978, 40 600 000 m^3/yr

Stream flow rate (max., mean, min.): As those reported in Table 4.

Depth of Withdrawal (if groundwater source): N/A

End Use (industrial, domestic or other): Industrial

Data Reference: Alberta Environment; Water Rights Branch; Syncrude

Surface or Groundwater Water Quality:

Athabasca River water quality

Parameter[a]	6/5/75	Parameter	6/5/75	Parameter[a]	6/5/75
pH	7.4	Iron (Ext)	0.4	Total Hardness (as $CaCO_3$)	148
Conductivity (s/cm)	295	Chloride	12	Silica	N/D
Total Suspended Solids	199	Bicarbonate	81	Nitrate -N	0.45
Potassium	2.2	Carbonate	N/D	Alkalinity (Total) (as $CaCO_3$)	66
Calcium	47	Sulphate	77	Fluoride	0.17
Magnesium	7				

Effluent Discharge

Alberta Environment Licence No.: Letter of Permission 74-MP-142

Type of Discharge (municipal, industrial or depressurization): Municipal

Receiving Body: Effluent is being stored in tailings ponds

Discharge Location: N/A

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge (seasonal volumes): No discharge

Pretreatment Provided: Aeration and contact stabilization

Data Reference: Alberta Environment, Municipal Engineering Branch; Syncrude

Effluent Quality (final): 2.5 day Biochemical Oxygen Demand @ 35°C (mg/L): 150 (Mar 17/79), 75 (Apr 21/79)
Suspended Solids (mg/L): 170 (Mar 17/79), 40 (Apr 21/79)

Continued ...

Table 14. Continued.

Effluent Discharge

Alberta Environment Licence No.: N/A

Type of Discharge (municipal, industrial or depressurization): Industrial

Receiving Body: Stored in tailings pond

Discharge Location: N/A

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge (seasonal volumes): No discharge

Pretreatment Provided: N/A

Data Reference: Syncrude

Effluent Quality (final): N/D

Remarks: Industrial and municipal wastes are being stored in tailings ponds with no discharge to river.

Effluent Discharge

Alberta Environment Licence No.: Letter of Permission 76-LP-003

Type of Discharge (municipal, industrial or depressurization): Mine depressurization and surface drainage

Receiving Body: Beaver Creek Reservoir to Athabasca River via Ruth Lake and Poplar Creek

Discharge Location: 92-10-W4

Depth of Disposal Well (if deep well disposal used): N/A

Quantity of Discharge (seasonal volumes): 2 100 000 m^3 (1978)

Pretreatment Provided: None

Data Reference: Syncrude, AOSERP Report 23, Syncrude Canada Ltd. Environmental Monograph 1977-3

Effluent Quality (final):

Summary of the chemical composition of mine depressurization water from Syncrude of Canada Limited, Lease 17, obtained from AOSERP Report No. 23

Parameter[a]	Mean	Range (L - H)	Parameter[a]	Mean	Range (L - H)
Ammonia - N	7.65	2.2 - 13.65	Nitrate - N	0.037	< 0.1 - 0.061
Bicarbonate	3150.29	1828.5 - 5427	pH (units)	7.55	6.9 - 9.1
Calcium	71.86	< 1.0 - 318	Ortho Phosphorus (as P)	0.06	< 0.005 - 0.242
Carbonate	27.18	0.0 - 396	Total Phosphorus (as P_4)	0.17	< 0.0005 - 1.74
Chloride	7615.47	2250 - 10500	Potassium	45.44	19 - 65
Conductivity (µs/cm)	25658.5	9400 - 48000	Silica	4.39	2.0 - 18.0
Fluoride	0.71	0.48 - 1.25	Sodium	5622.23	2150 - 7900
Total Hardness (as $CaCO_3$)	741.58	295 - 1377	Sulphate	10.22	< 0.5 - 78
Magnesium	133.89	47 - 253	Sulphide	0.051	< 0.02 - 0.11
Nitrite -N	< 0.1	< 0.1 - N/D	Total Inorganic Carbon	579.19	250 - 820

Continued ...

Table 14. Continued.

Summary of the chemical composition of mine depressurization water from Syncrude of Canada Limited, Lease 17, obtained from AOSERP Report No. 23 (late 1976) - Cont'd

Parameter[a]	Mean	Range (L - H)	Parameter[a]	Mean	Range (L - H)
Total Alkalinity (as $CaCO_3$)	2628.78	1524 - 4452	Total Filterable Residue Fixed	16268.39	5376 - 19140
Biochemical Oxygen Demand	3.67	2.0 - 8.0	Total Non-Filterable Residue	55.84	< 0.4 - 436
Carbon (Total)	757.31	474 - 1130	Total Non-Filterable Residue Fixed	47.33	< 0.4 - 394
Chemical Oxygen Demand	231.4	10 - 1282	Turbidity (JTU)	32.16	< 0.01 - 298
Humic Acid	1.17	< 1.08 - 1.36	Aluminum (Total)	0.16	< 0.005 - 2.3
Hydrocarbon (Total)	15.01	< 0.001 - 324	Arsenic (Total)	0.004	0.0002 - 0.02
Total Kjeldahl Nitrogen	11.37	4.8 - 22.9	Boron (Total)	2.60	0.48 - 7.08
Oil and Grease	2.43	< 0.1 - 36.3	Cadmium (Total)	0.013	< 0.001 - 0.053
Phenol	0.0055	< 0.0001 - 0.029	Chromium (Total)	0.008	< 0.002 - 0.036
Polychlorinated Biphenyls	0.00015	< 0.0001 - 0.0006	Cobalt (Total)	0.05	< 0.002 - 0.165
Surfactants	0.32	< 1.02 - 188	Copper (Total)	0.015	< 0.001 - 0.032
Tannin and Lignin	0.62	< 0.1 - 2.0	Iron (Total)	1.51	< 0.04 - 7.45
Total Organic Carbon	189.42	< 1.0 - 9319	Lead (Total)	0.028	< 0.002 - 0.142
Colour	25.31	5 - 98	Manganese (Total)	0.194	0.65 - 1.2
Colour (T_2)	98.62	98 - 99	Mercury (Total)	0.0034	< 0.0001 - 0.07
Colour (T_3)	96.62	96 - 97	Nickel (Total)	0.059	< 0.002 - 0.32
Odour	17.31	2 - 100	Selenium (Total)	0.0014	< 0.005 -0.0037
Total Dissolved Solids	15561.16	9319 - 19245	Silver (Total)	0.011	< 0.001 - 0.05
Total Residue	15479.32	8810 - 19330	Vanadium (Total)	0.004	< 0.001 - 0.02
Total Filterable Residue	14688.68	5768 - 19240	Zinc (Total)	0.024	< 0.001 - 0.2

Analysis of mine depressurization water from five wells from Syncrude of Canada Limited, Lease 17[b] obtained from AOSERP Report No. 23 (late 1976)

Parameter[a]	14/9/76	30/11/76	Parameter[a]	14/9/76	30/11/76
Original Carbon	35	24	Chlorinated Hydrocarbons	0.01	0.006
Extractable Carbon	21	16	Organic Nitrogen Compound	0.014	0.029
Residual Carbon	14	8	Aldehydes	0.48	0.54
Percentage of Carbon Extracted	60	64	Amides	0.36	0.27
Asphaltenes	3.41	1.80	Ketones	0.01	0.01
Alkanes and Alkenes	0.11	0.01	Quiones	0.45	0.55
Aromatics	0.60	0.02	Esters	1.15	1.34
Polar Compounds	0.03	0.02	Phenols Colorimetric	0.003	0.001
Sulphur Compounds	2.7	3.3	Phenols by GC	0.19	0.19
Elemental Sulphur	0.001	0.001	Organic Acids	1.1	2.6
Phosphorus Compounds	0.0001	0.0001			

[b] Adapted from original tables in Strosher (1976).

Continued ...

Table 14. Continued.

Characteristics of saline water discharged into Beaver Creek from ponds by the test pit, obtained from Syncrude Canada Ltd., Environmental Monograph 1977-3

Parameter[a]	3/9/75	9/9/74	17/9/74	24/9/74
Cl^- (mg/L)	2 300	2 550	2 480	2 330
Oil and Grease (mg/L)	1.3	2.7	N/D	3.7
pH	8.2	8.6	8.4	8.6

All samples collected immediately downstream of discharge to Beaver Creek.
Pumping from test pit ceased 1 October 1975.
Estimated quantity for September 1975 - 16 986 m^3.

Results of water chemistry analysis for groundwater from wells on Syncrude Lease 17 including Well 2600S, 4800E and other wells in the vicinity. Obtained from Syncrude Canada Limited, Environmental Monograph 1977-3

Parameter[a]	2600S	4800E	n=4	Wells in area		n=72
		Range			Range	
	mean	high	low	mean	high	low
Sodium	4 242.0	4 500	3 885	3 517.0	10 698	564
Potassium	38.5	48	31	33.0	112	4
Calcium	48.5	96	14	56.0	316	3
Magnesium	51.3	59	35	69.6	411	3
Chloride	4 488.0	4 807	3 890	4 560.0	19 854	19
Bicarbonate	3 188.0	3 523	2 626	2 016.7	3 431	532
Sulfate	30.0	49	19	66.5	377	0
Carbonate	166.0	446	Nil	494.0	1 230	0
Silica	N/D	N/D	N/D	22.4	27	18
Phosphate (as P)	N/D	N/D	N/D	0.3	0.41	0.17
Nitrates -N	N/D	N/D	N/D	0.3	0.75	0.2
Aluminum	<1.00	N/D	N/D	1.60	5.20	<0.01
Arsenic	<0.01	N/D	N/D	<0.01	N/D	N/D
Barium	0.10	0.20	N/D	<1.00	N/D	N/D

Parameter[a]	2600S	4800E	n=4	Wells in area		n=28
		Range			Range	
	mean	high	low	mean	high	low
Boron	4.30	5.30	3.50	5.80	8.00	2.00
Cadmium	<0.01	0.01	<0.01	<0.05	0.32	<0.01
Chromium	<0.01	N/D	N/D	<0.01	N/D	N/D
Cobalt	<0.03	0.07	<0.01	<0.01	N/D	N/D
Copper	<0.01	0.01	<0.01	<0.01	N/D	N/D
Iron	0.93	0.10	0.75	11.40	128.00	<0.01
Lead	<0.10	0.26	<0.01	0.05	0.22	<0.01
Manganese	<0.01	0.01	<0.01	0.90	6.63	<0.01
Mercury (ppb)	1.10	2.20	<0.20	<0.20	N/D	N/D
Nickel	<0.02	N/D	N/D	<0.02	N/D	N/D
Titanium	<1.00	N/D	N/D	<1.00	N/D	N/D
Vanadium	<1.00	N/D	N/D	<1.00	N/D	N/D
Zinc	0.02	0.02	<0.01	0.65	7.51	<0.01
Total Dissolved Solids	12 262	13 537	10 504	10 864	36 613	1 146

(ppb) - Parts per billion
All metals are reported as totals.
Sampling dates: April to October 1975

Table 14. Concluded.

Chemical analysis of Syncrude groundwater precipitate from unidentified well, obtained from Syncrude Canada Ltd., Environmental Research Monograph 1977-3 (October 1975 data).

Parameter	Lower Concentration Limit (ppm)	Number 144-03-03	Parameter	Lower Concentration Limit (ppm)	Number 144-03-03
Antiomny	50	bcl	Magnesium	0.02%	0.2%
Arsenic	50	bcl	Manganese	5	200
Barium	5	2,000	Molybdenum	10	bcl
Beryllium	5	bcl	Nickel	5	50
Bismuth	5	bcl	Niobium	50	bcl
Boron	20	2,000	Silver	1	2
Cadmium	20	bcl	Strontium	20	1,000
Calcium	0.05%	0.5%	Tantalum	200	bcl
Chromium	10	bcl	Tellurium	200	bcl
Cobalt	10	10	Thorium	100	bcl
Copper	1	50	Tin	10	20
Gallium	2	5	Titanium	5	500
Germanium	20	bcl	Vanadium	10	20
Iron	0.05%	1.0%	Zinc	50	2,000
Lead	5	50	Zirconium	20	bcl

Concentration Range

> 5 000 ppm = >5 000 ppm	200 ppm = 100 - 400 ppm	5 ppm = 2 - 10 ppm
5 000 ppm = 2 500 - 10 000	100 ppm = 50 - 200 ppm	2 ppm = 1 - 4 ppm
2 000 ppm = 1 000 - 4 000	50 ppm = 25 - 100 ppm	1 ppm = 0.5 - 2 ppm
1 000 ppm = 500 - 2 000 ppm	20 ppm = 10 - 50 ppm	
500 ppm = 250 - 1 000 ppm	10 ppm = 5 - 20 ppm	

bcl = below concentration unit
Ranges for iron, calcium, and magnesium are reported in %.

Analyses of gaseous components of groundwater from Syncrude Lease 17, obtained from Syncrude Canada Ltd., Environmental Research Monograph 1977-3 (October 1975 data).

Parameter	No. of Samples	Mean (mol %)	Range High	Range Low	Parameter	No. of Samples	Mean (mol %)	Range High	Range Low	Parameter	No. of Samples	Mean (mol %)	Range High	Range Low
He_2	5	0.01	0.04	0.00	C_1	6	83.90	91.70	70.80	iC_5	5	0.05	0.22	0.00
He	3	0.00	N/D	N/D	C_2	6	0.34	1.70	0.05	C_5	5	0.01	0.05	0.00
N_2	5	4.30	11.61	0.00	C_3	6	0.12	0.57	0.00	C_6	5	0.07	0.33	0.00
CO_2	6	11.70	28.70	5.70	iC_4	6	0.01	0.06	0.00	C_{7+}	5	0.20	0.52	0.00
H_2S	6	0.00	N/D	N/D	C_4	6	0.08	0.34	0.00					

[a] All values are actual and reported in mg/L unless otherwise indicated
< - Less than; N/D - No data; N/A - Not applicable

Table 15. Summary of water uses and effluent discharges in the AOSERP study area associated with Texaco Canada Inc.

Operator: Texaco Canada Inc.

Area: McMurray

Location (Legal): 17-88-8-W4

Water Withdrawal

Alberta Environment File No.: 14353 Industrial

Source (surface or groundwater): Saline Creek

Source Location: 15-88-8-W4

Licenced Withdrawal (volume): 370,000 m^3/yr

Actual Withdrawal (m^3): 1972, 94,000; 1973, 91,900; 1974, 117,600; 1975, 80,800; 1976, 174,500; 1977, 232,500; 1978, 194,800

Stream Flow Rate (max., mean, min.): Mean, 0.28 m^3/sec; Min., always greater than 0.056 m^3/sec.

Depth of Withdrawal (if groundwater source): N/A

End Use (industrial, domestic or other): Boiler feedwater for steam generation (for injection purposes)

Data Reference: Texaco Canada Inc.; Alberta Environment, Water Rights Branch

Surface or Groundwater Quality:

Saline Creek Water Quality Obtained From AOSERP

Parameter [a]	16/5/76	10/8/76	13/10/76	16/11/76	22/12/76	27/4/77	18/5/77	9/6/77
pH (Field)	7.6	N/D	N/D	N/D	N/D	N/D	7.7	N/D
pH (Lab)	8.0	7.0	7.5	7.6	8.0	7.6	7.7	7.8
Temperature Field ^oC	12	18	N/D	0	0	6.5	6.5	14.0
Temperature (Lab) ^oC	15.1	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Conductivity Field - (µs/cm)	240	193	N/D	N/D	N/D	150	79	N/D
Conductivity Lab (µs/cm)	230	194	171	310	720	149	167	149
Oxygen Dissolved	N/D	9.8	N/D	N/D	N/D	N/D	12.4	10.2
Calcium	26.8	22.0	19.0	36.5	91.0	14.0	17.0	15.5
Magnesium	9.2	7.5	6.4	13.2	31.0	5.0	6.0	5.5
Sodium	16.3	16.0	13.4	20.0	36.5	13.0	11.5	12.0
Potassium	1.2	0.9	0.3	0.7	2.0	1.9	0.9	0.2
Chloride	6.8	1.5	8.7	8.6	10.1	7.1	4.6	3.9
Sulphate	8.4	9.5	3.8	14.3	65.5	6.0	9.6	9.6
Alkalinity Phenolphthalein ($CaCO_3$)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkalinity - Total ($CaCO_3$)	104	101.0	78.4	148.6	348.0	62.8	71.6	70.4
Carbonate (Calcd) (CO_3)	0	0	0	0	0	0	0	0
Bicarbonate (Calcd) (HCO_3)	127	123	96	181	424	77	87	86
Total Hardness (Calcd) ($CaCO_3$)	104.8	85.8	73.8	145.5	354.9	55.5	67.2	61.2
Dissolved Fluoride	0.09	0.09	0.07	0.13	0.16	0.08	0.07	0.09
Odor Threshold No.	N/D	4	4	2	2	4	2	2
Color Apparent - (rel. units)	N/D	100	125	120	50	100	130	170
Tannin and Lignin	N/D	2.45	2.15	0.65	1.00	1.9	2.00	2.50
Surfact N - Alkalinity Sulphants	N/D	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Total Phosphorus - (P)	N/D	0.33	0.23	0.03	0.03	0.23	0.33	0.07

Continued ...

Table 15. Continued.

Parameter	16/5/76	10/8/76	13/10/76	16/11/76	22/12/76	27/4/77	18/5/77	9/6/77
Ortho - Phosphorus PO_4 - (P)	N/D	0.22	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Residue Filterable	209	142	110.0	190	522.5	95	110	98.4
Residue Fixed Filterable	90	127	85.0	162	327.5	69	61	63
Residue Non Filterable	79	215	184.0	8.0	6.4	244	454.0	77.2
Residue Fixed Non Filterable	70	200	168.8	5.6	3.6	218	415.0	67.6
Turbidity (JTU)	31	128	N/D	8.5	3.5	200	280	46
Silica Reactive (SiO_2)	2.0	7.5	6.7	10.5	114	2.3	3.1	2.8
Sulphide Dissolved $-^2$(S)	N/D	< 0.05	< 0.05	< 0.05	< 0.05	N/D	N/D	N/D
Chlorophyll - a	N/D	N/D	< 0.001	< 0.001	< 0.001	N/D	N/D	N/D
Humic Acid Extractable	3	7.0	7.0	3	< 1.0	1.0	4.0	3.5
Fulvic Acid Extractable	27	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Fulvic Acid Dissolved	0.012	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Total Organic Carbon	29	37	34.0	38	17	14	42	27.5
Total Inorganic Carbon	23	19	14.0	26	67	11	13	13
Dissolved Organic Carbon	25	N/D	30.0	37	17	14	38	25.5
Dissolved Inorganic Carbon	23	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Nitrate + Nitrite - (N)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ammonia - (N)	N/D	0.16	0.20	0.10	0.25	0.10	0.05	0.05
Total Kjeldahl Nitrogen - (N)	N/D	1.50	0.97	0.68	0.81	0.98	1.38	1.45
Dissolved Nitrogen - (N)	0.56	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Phenolic Material	0.012	0.016	0.006	0.002	0.002	0.005	0.003	0.002
Oil and Grease	N/D	< 0.1	0.7	< 0.1	< 0.1	0.8	0.7	0.2
Chemical Oxygen Demand	N/D	123.7	180.0	66	72	59	79	68
Chromium Hexavalent	N/D	0.006	0.006	< 0.003	< 0.003	0.012	0.006	< 0.003
Chromium (Ext)	< 0.015	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Cadmium (Ext)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cadmium (Diss)	< 0.001	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Copper (Ext)	0.003	0.008	0.006	0.002	0.011	0.010	0.016	0.004
Copper (Diss)	< 0.001	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Iron (Ext)	1.21	5.3	5.20	0.96	0.74	5.65	7.60	2.4
Iron (Diss)	0.26	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Lead (Ext)	0.005	0.008	0.004	< 0.002	< 0.002	< 0.002	< 0.002	0.002
Lead (Diss)	0.004	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Cyanide	N/D	< 0.001	< 0.001	< 0.001	< 0.001	N/D	N/D	N/D
Manganese (Ext)	0.047	0.100	0.071	0.053	0.16	0.082	0.190	0.045
Manganese (Diss)	0.010	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Silver (Ext)	N/D	< 0.005	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	< 0.001
Zinc (Ext)	0.007	0.038	0.027	0.006	0.014	0.030	0.061	0.017
Zinc (Diss)	< 0.001	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Vanadium (Total)	0.004	N/D	N/D	< 0.001	< 0.001	0.006	< 0.001	0.002
Vanadium (Ext)	N/D	< 0.001	0.004	N/D	N/D	N/D	N/D	N/D
Vanadium (Diss)	0.002	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Selenium (Diss)	< 0.0005	N/D	N/D	< 0.0005	< 0.0005	< 0.0005	0.0009	0.0006
Selenium (Ext)	0.0025	0.0022	N/D	N/D	N/D	N/D	N/D	N/D
Mercury (Total)	N/D	< 0.0002	< 0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002
Mercury (Ext)(ug/L)	0.05	N/D	N/D	N/D	N/D	N/D	N/D	N/D

Continued ...

Table 15. Continued.

Parameter	16/5/76	10/8/76	13/10/76	16/11/76	22/12/76	27/4/77	18/5/77	9/6/77
Arsenic (Total	N/D	0.006	0.020	N/D	N/D	N/D	N/D	N/D
Arsenic (Diss)	N/D	N/D	N/D	<0.001	0.003	<0.0005	<0.0005	<0.0005
Nickel (Ext)	0.010	0.005	<0.002	<0.002	<0.002	<0.002	0.012	<0.002
Nickel (Diss)	0.004	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Aluminium (Ext)	0.52	3.20	2.45	0.17	0.04	2.20	7.60	1.65
Cobolt (Ext)	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002
Cobolt (Diss)	<0.002	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Boron (Diss)	0.16	0.30	0.03	0.08	0.10	0.19	0.12	0.18
Barium (Ext)	<0.05	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Molybdenum (Ext)	<0.10	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Strontium (Ext)	0.12	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Beryllium (Ext)	<0.05	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Beryllium (Diss)	<0.005	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Carbon Dioxide Free (Calcd)	2.0	19.6	4.8	7.2	6.7	3.0	2.8	2.1

Effluent Discharge

Alberta Environment Licence No.: N/A

Type of Discharge: Produced water from steam flood

Receiving Body: Granite Wash Formation

Discharge Location: 13-15-88-8-W4

Depth of Disposal Well (if deep well disposal used): 41.9 m^{KB}

Quantity of Discharge (m^3): 1973, 6 200; 1974, 5 200; 1975, 33 200; 1976, 55 600; 1977, 121 000; 1978, 129 000

Pretreatment Provided: None

Data Reference: Texaco Canada Inc., Chemex Lab.

Effluent Quality (final):

Discharge water quality

Parameter[a]	5/12/76	Parameter[a]	5/12/76
pH	7.4	Sodium	320
Conductivity (micromhos/cm)	1520	Potassium	9.7
Total Dissolved Solids @ 220°F	1428	Calicum	7.2
Total Dissolved Solids @ 900°F	980	Magnesium	1.2
Total Suspended Solids	718	Bicarbonate	369
Total Hardness (as $CaCO_3$)	23.1	Chloride	253
Total Alkalinity	302	Sulphate	63

Continued ...

Table 15. Concluded.

Parameter	5/12/76	Parameter	5/12/76
Iron (Ext)	0.4	Total Inorganic Carbon	38
Total Phosphate (as P)	0.24	Silica	175
Total Carbon	410	Oil and Grease	304.7
Colour (APHA)	1500	Vanadium (Ext)	0.004
Tannin and Lignin	122	Copper (Ext)	0.005
Ammonia -N	14.5	Nickel (Ext)	0.004
Total Kjeldahl Nitrogen -N	15.9	Lead (Ext)	0.013
		Zinc (Ext)	0.008

[a] All values are actual and reported as mg/L unless otherwise indicated.
(Ext) - Extractable
(Diss) - Dissolved
(Calcd) - Calculated
< - Less than

Table 16. Summary of water uses and effluent discharges in the AOSERP study area associated with Union Oil Company of Canada Ltd.

Operator: Union Oil Company of Canada Ltd.

Area: Buffalo Creek

Location (Legal): 5-88-19-W4

Water Withdrawal

Alberta Environment File No.: 19223

Source (surface or groundwater): Aquifer

Source Location: 5-88-19-W4, 8-88-19-W4

Licenced Withdrawal (volume): 71 514 m^3/yr

Actual Withdrawal (seasonal volumes): 1977,212 000 m^3; 1978,7 972 m^3; to 30, May 1979,2 050 m^3

Stream Flow Rate (max., mean, min.): N/A

Depth of Withdrawal (if groundwater source): 30 m

End Use (industrial, domestic or other): water supply for camp and steam injection

Data Reference: Union Oil Company of Canada Ltd.; Alberta Environment, Water Rights Branch

Surface or Groundwater Water Quality:

Groundwater quality

Parameter[a]	7/2/77	Parameter[a]	7/2/77
pH	7.7	Bicarbonate	476
Conductivity @ 25°C (micromhos/cm)	662	Carbonate	0
Total Dissolved Solids	638	Sulphate	14
Sodium	25	Hydroxide	0
Calcium	94	Total Hardness (as $CaCO_3$)	352
Magnesium	29	Silica	20
Iron (Ext)	1.2	Plate Count	180,000/mL
Chloride	1		

Effluent Discharge

Alberta Environment Licence No.: N/A

Type of Discharge: Water produced from gas wells

Receiving Body: Grosmont Unit 2 Formation (deep well disposal)

Discharge Location: 3-88-19-W4

Depth of Disposal Well (if deep well disposal used): 299 m

Quantity of Discharge (seasonal volumes): 1978, 12 100

Pretreatment Provided: None

Data Reference: Union Oil Company of Canada Ltd.

Table 16. Concluded.

Effluent Quality (final):

Discharge water quality

Parameter[a]	15/1/79	Parameter[a]	15/1/79
pH	9.1	Magnesium	35
Total Dissolved Solids (evaporated)	5230	Iron (Diss)	present
Total Dissolved Solids (ignited)	4260	Chloride	1577
Total Dissolved Solids (calculated)	6068	Bicarbonate	2228
Sodium and Potassium	1969	Carbonate	216
Calcium	8	Sulphate	35
		Hydroxide	0
		Hydrogen Sulphide	0

[a] All values are actual and reported as mg/L unless otherwise indicated.
(Diss) - Dissolved
(Ext) - Extractable
N/A - Not applicable

4. HYDROLOGIC AND HYDRAULIC CONSIDERATIONS

The major users of water associated with oil sands development in Alberta are the existing full-scale oil sands plants, pilot plants, and urban communities.

Surface and groundwater are used for water supply and as a receiving water for effluent discharge. The data inventory, reported in the preceding section, revealed that the use of groundwater generally is limited to pilot plants and that most of the required water is obtained from surface sources. In addition, it was shown that most effluents are discharged to surface waters, although some operations maintain deep well disposal systems.

The data inventory also identified that the Athabasca River is the major water source and receiving water for the oil sands operations. It is apparent that future plants (i.e., Alsands) will be dependent on Athabasca River water. Consequently, the availability of water as a supply and receiving water for wastes should be perceived.

Sections 4.1 and 4.2 addresses the streamflow balance and water quality considerations based on the inventory data reported in the previous section.

4.1 STREAMFLOW BALANCE

The streams associated with oil sands developments have been the subject of several hydrologic and hydraulic investigations.

Streamflow and water level data, acquired by Water Survey of Canada (WSC) for the period of record to the end of 1978, have been reported by Loeppky and Spitzer (1977), Warner and Spitzer (1979), and Warner (1979). These investigations indicate that approximately 20 years of discharge data are available for the Clearwater River above Fort McMurray and the Athabasca River below Fort McMurray. Fewer data (seven years or less) are available for the remaining rivers and creeks in the area.

Neill and Evans (1979) indicated that, due to the short period of record of the WSC data, an accurate assessment of the temporal and spatial variations of streamflow is not possible at the present time.

Extreme events require 20 to 30 years of record to provide a basis for a reasonably accurate statistical analysis; mean annual flow estimations require approximately five years of data. Neill and Evans (1979) found that the record minimum flows in the study area were erratic and did not correlate well with drainage area due to the shortness of record. They also indicated that the hydrometric data collection network presently in service is adequate.

The Athabasca River has been the subject of investigations by the Alberta Research Council in their studies of transverse mixing in natural streams (Beltaos 1978). He presented methods for the analysis of the dispersion of neutral substances. Field tests to establish transverse mixing coefficients for the Athabasca River and other rivers under ice-cover and open-water conditions were documented. One of the Athabasca River field tests took place in the reach from the Mildred Lake dock, near Syncrude, to the mouth of the MacKay River.

4.1.1 Athabasca River Streamflow Balance

Flows in the Athabasca River are monitored by WSC at stations downstream of Fort McMurray and at Embarras Airport; the drainage area tributary to these stations are 133 000 km^2 and 155 000 km^2, respectively. Most of the present and future major water users (i.e., GCOS, Syncrude, the proposed Alsands plant, and the McClelland Lake Townsite) are located along this reach.

The area tributary to the Athabasca River in the reach between Fort McMurray and Embarras Airport is 22 000 km^2. This is about 14% of the area tributary to the Athabasca River at Embarras Airport. Streamflow data are available for the rivers and creeks draining all but 15% of this local tributary area.

Neill and Evans (1979), using data to the end of 1977, established a mean annual streamflow balance for the Athabasca River. Utilizing data available to the end of 1978, the mean annual streamflow balance has been recomputed and streamflow balances for the mean annual minimum daily discharge and the one in 20-year return minimum daily discharge have been estimated (Figure 4). As indicated by Neill and Evans (1979), the length of record for the tributary areas is too short

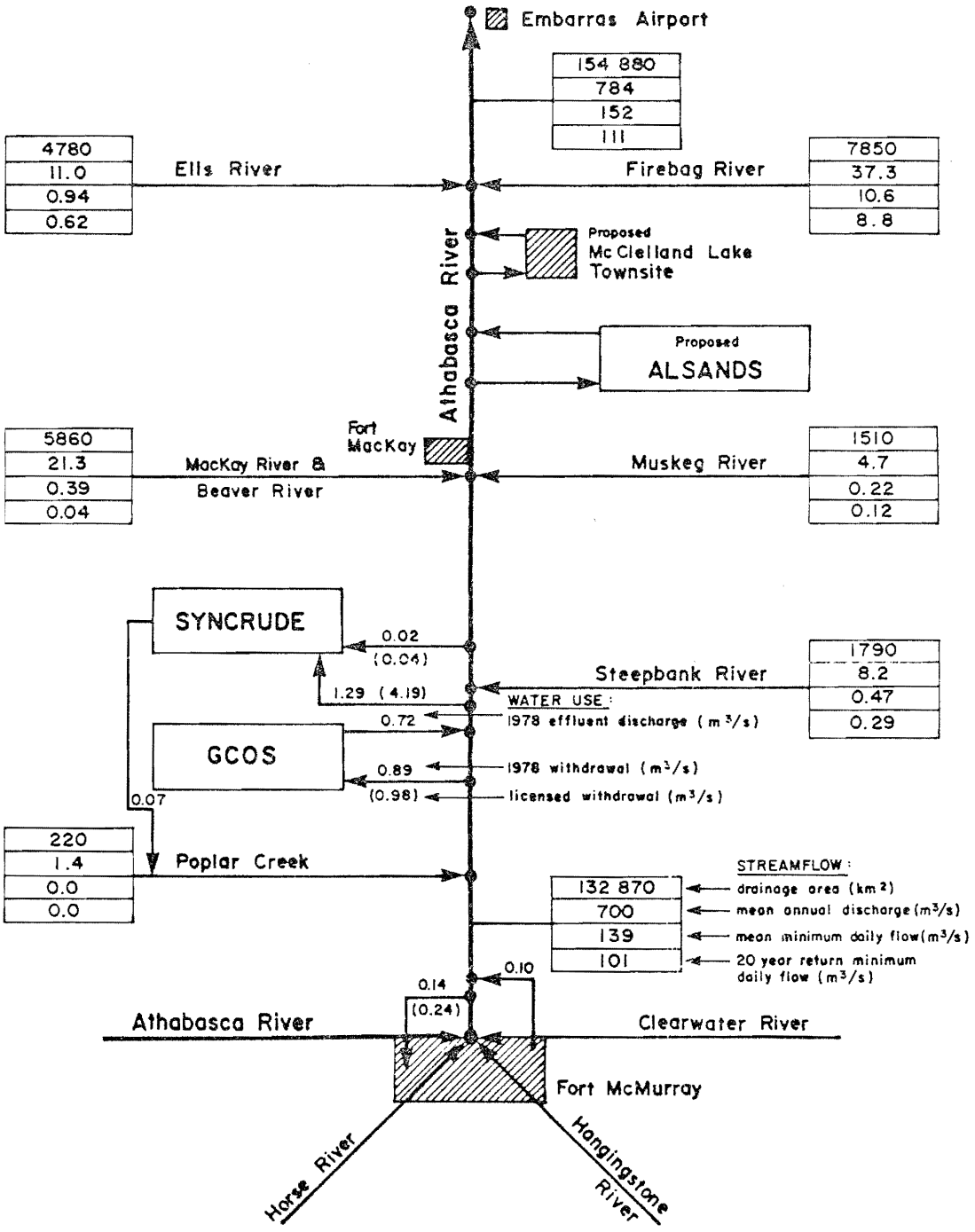

Figure 4. Athabasca River streamflow balance schematic.

for accurate predictions of their minimum daily flows during the one in 20 years return event. However, sufficient data are available for the Athabasca River below Fort McMurray. Since this station comprises 85% of the area tributary to the Athabasca River at Embarras Airport, the uncertainty associated with the one in 20-year return minimum daily flows along this reach of the Athabasca River is small.

The existing major water users in the area and the two proposed users, the Alsands plant and the McClelland Lake Townsite, also are depicted on Figure 4. In contrast to streamflows, annual water withdrawals and effluent discharges are increasing with the increased number and the increased level of oil sands developments. Water withdrawals and effluent discharges are government regulated (i.e., Water Licence). The terms of the regulations are updated periodically according to the operational levels of the water users. The present and potential water use, as indicated by the water withdrawal and effluent discharge during 1978, and the licenced withdrawals are shown on Figure 4.

Currently, water users from the Athabasca River downstream from Fort McMurray withdraw water at an annual rate of 2.34 m^3/s. The water licences of these users allow a total diversion of 5.45 m^3/s. The proposed Alsands water requirement has been estimated at 2.35 m^3/s (Stanley Associates Engineering Ltd. 1975). Downstream of Alsands, the proposed McClelland Lake townsite will withdraw water for municipal purposes; it is reported that the new town will approach the size of Fort McMurray in the 1990's (Stanley Associates Engineering Ltd. 1976). Thus, the potential water diversion from the Athabasca River in the near future is 8.0 m^3/s. This is about 7% of the one in 20-year return minimum daily flow (111 m^3/s) at Embarras Airport.

Effluent discharge to the Athabasca River by the present water users is 0.89 m^3/s. This means that 38% of the water presently withdrawn from the Athabasca River is returned as effluent. The remainder comprises consumptive use in the municipal and industrial systems as well as storage in the Syncrude lagoons. The potential effluent discharge quantities cannot be estimated without knowledge of the water use processes utilized by the major water users.

4.2 ATHABASCA RIVER WATER QUALITY CONSIDERATIONS

The inventory data may aid in determining the existing and predicting the future water quality of the Athabasca River. The methods by which this can be accomplished are as follows.

An accurate assessment of the water quality of the Athabasca River based on inventory data is difficult without detailed supporting information. The background concentrations of the various parameters at locations along the river must be identified. Furthermore, it is imperative to have all data required for assessment obtained concurrently during particular sampling periods in order to identify seasonal variations. However, with respect to water quality of the Athabasca River, as a principal function, the inventory data provide a historical summary of the quality, quantity and operational characteristics associated with each of the oil sand developments.

In predicting water quality of a receiving stream, the processes that should be addressed are dispersion, dilution, biological and chemical assimilation, and loss to sediment. Through the use of the following dilution formula, gross concentrations of certain parameters may be obtained:

$$C = \frac{C_o Q_o + C_e Q_e}{Q_o + Q_e}$$

In this equation, C denotes concentration of a parameter, Q denotes flow, and the subscripts o and e denote the river and effluent conditions prior to the effluent discharge. It should be recognized that water quality assessments based on this equation alone assume that mixing of the effluent occurs over a short distance downstream of the outfall and that assimilation of the effluent by methods other than dilution does not occur. In addition, the equation makes no allowance for the dispersion of effluent characteristics. The dispersion may vary considerably exhibiting a condition where an effluent follows along one stream bank for large distances with only limited lateral mixing.

Although the inventory data may provide the required values for the dilution formula, other information, such as dispersion, biological and chemical assimilation, and loss to sediment, would be required for predicting water quality.

5. DATA BASE MANAGEMENT SYSTEMS

5.1 BACKGROUND

In providing a review of the commonly available data base management systems (DBMS), the goals were established according to the following, in chronological order:

1. Define the requirements for a DBMS for use by Alberta Environment;
2. Review criteria for evaluating a DBMS;
3. Compare existing DBMS with the requirements and establish evaluation criteria; and
4. Recommend a DBMS best suited for Alberta Environment.

A literature survey was conducted to familiarize with current concepts of DBMS evaluation (Appendix 8.1). Subsequently, the method reported in Kuss and Madill (1971) was adapted.

The large number of data base management systems currently available and marketed by numerous companies has resulted in a proliferation of terminology. As an aid, the commonly used synonyms, indicated in parentheses, referred to by different companies are defined and shown in Appendix 8.2.

5.2 SYSTEMS AVAILABLE

Currently, a large number of packages or systems are available and perform a diverse set of functions. These packages are marketed under a variety of names such as file management systems, information retrieval systems, generalized information systems, and information management systems. In general, these systems fall into four basic categories: (1) Information Retrieval Systems; (2) Data Base Access Systems; (3) Generalized Data Management Systems; and (4) Generalized On-Line Information Systems (Kuss and Madill 1971). A description of the features and attributes of each category is as follows.

5.2.1 Information Retrieval Systems

An information retrieval system provides the basic functions of inquiry and retrieval from an existing data base. In general, the data bases are not complex in structure. Another feature of these systems is the ability to produce reports easily and efficiently. File creation or maintenance facilities are not usually provided in information retrieval systems.

5.2.2 Data Base Access Systems

The data base access system attempts to provide efficient access methods for disk file organization. Files are integrated within the data base and file relationships are maintained by the system. Retrieval and maintenance facilities are not usually provided.

5.2.3 Generalized Data Management Systems

A generalized data management system provides file definition, creation, and maintenance facilities as well as information retrieval and report generation capabilities. Furthermore, data are independent of application programs and an easy to use (English-like) query language is available for interrogating the data base. However, these systems do not usually maintain file relationships automatically.

5.2.4 Generalized On-Line Information Systems

Generalized on-line information systems are designed primarily to provide common teleprocessing message control routines to simplify teleprocessing applications. Data are independent of application programs. File creation, update, and maintenance facilities may be provided. These systems do not usually provide generalized inquiry features or report generating functions.

5.3 SYSTEM REQUIREMENTS BY ALBERTA ENVIRONMENT

Based on the nature of the data (water use and effluent discharge) considered in this study, the DBMS must be capable of

providing the following functions and is the combination of the four system types described in Section 5.2:

1. The ability to define, create, and maintain the files in the data base;
2. An inquiry and retrieval facility to access and maintain a data base;
3. The ability to produce reports from the data base;
4. Batch and on-line symmetry for accessing the data base;
5. Access to the data base from high-level programming languages; and
6. An integrated data base that maintains inter-file relationships.

5.4 EVALUATION CRITERIA

The following criteria were employed in evaluating the DBMS according to the guidelines established by Association for Computing Machinery (1969).

5.4.1 Security

A DBMS should provide security from access or modification at all levels, simply protecting the file at the file level, record level, segment level, and data element level. The security should be exclusive at all levels and between users; a user with access to certain data or files is assigned access and modification privileges for each segment and data element available to the user, while another user may have different access and modification privileges to the same set of data or subset thereof.

5.4.2 Audit Trails

The DBMS should be capable of providing an audit trail for logging or monitoring all transactions to the data base or file. Transaction statistics on data base files are also desirable.

5.4.3 Data Base Concepts

File Structures: The DBMS should allow for definition of network, hierarchic, and sequential file structure.

Record Formats: The record formats available to users should include fixed and variable length records with multiple occurrences of fields. The DBMS should provide a logical record capability.

Data Element Format: Fixed and variable length of data elements should be permitted. The data types available should include character, zoned decimal and packed decimal, and fixed binary and floating point binary.

5.4.4 Data Base Language (DBL)

Inquiry Facilities: The inquiry facility should be a simple, easy to use (English-like) language for use in interrogating the data base. It is desirable that this be free-form and procedural. In on-line inquiry, the DBL should provide some prompting for missing information and the DBL design should be such that a user may proceed intuitively to formulate a request if a memory lapse should occur.

Update and Maintenance Facility: The ability to define, create and maintain files from within the DBL should be available to the user. The facility to add, delete, insert and modify records, and data elements should be provided. Input data checking or editing is desirable.

Logical Arithmetic, and Sort Facility: There should exist logical and arithmetic capabilities for use in record selection and data base inquiry. Moreover, a sort facility should be available to present the records selected sorted according to data element values.

5.4.5 Report Generation

Producing reports from the data base should be accommodated easily including summary information and function evaluation such as totals, sub-totals, means, etc.

5.4.6 Programming Language Interface

The data base should be accessible from high-level programming languages through this interface bypassing the DBL. All functions of the DBL should be available in this manner. Also, the ability to invoke user sub-routines written in other programming languages from within the DBL is desirable.

5.4.7 System Stability

Integrity. Since hardware and software can never be eliminated, the DBMS should minimize the time during which a data base is vulnerable to damage. Moreover, the DBMS should attempt to detect errors quickly and recover from them if possible. It is absolutely essential that the data base can be restored after it has been damaged. Recovery procedures may be automatic or manual but it is desirable that the data base can be restored without the user being required to re-submit and re-process all transactions, since the data base was damaged. Automatic recovery and automatic back-up are desirable.

5.4.8 Service Bureau Co-operation and Support

The service bureau representatives should be available and have a full working knowledge of their DBMS if problems occur. Training sessions should be provided for all levels of user experience. When asked for information, the service bureau should provide a professional report tailored to the needs of the user. It is undesirable for the service bureau to answer all requests for information by sending out highly technical system manuals.

5.5 SYSTEMS EVALUATION

The first stage in the evaluation process involved the assigning of weights to the evaluation criteria, according to the relative importance of each criterion. Those criteria deemed to be "needs" were assigned weights ranging 6 to 10 while the criteria in the category of "wants" were assigned weights ranging 1 to 5.

The second step involved a survey of candidate systems and summarized their features with respect to the evaluation criteria (Appendix 8.3). Subsequently, each system was compared according to the evaluation criteria and assigned a rank value. The method of determining a rank value, according to Kepner and Tregoe (1965) is as follows.

A unique rank of r of n items is assigned a rank value of n - r. If m items are tied at rank j then the m items are assigned a rank value equal to the mean of the rank values for the next m rank. The next rank that can be assigned is then m + j.

Example: Assume five items are to be rank ordered from 1 to 5 according to some criteria. Further, assume that three of the five items are tied for second. The determination of the rank values for the five times is as follows: the item with r = 1 is assigned a rank value of 5 - 1 = 4. The three items with r = 2 are assigned the rank values [(5-2) + (5-3) + (5-4)] / 3 = 2. The item ranked last is assigned a rank value of 5 - 5 = 0.

The assignment of ranks to the candidate system is relative and subject to a value judgement. However, the following rule has been applied as objectively as possible: "For a given criterion if the systems are significantly different, they can be ranked accordingly. If any of the systems are not significantly different, or undistinguishable according to our criteria, they will be assumed to be tied."

The final step in the evaluation involved computing the sum of the weight times the rank value for each criterion to establish a total score for each of the DBMS evaluated. The following data base management service companies and their respective systems were evaluated:

1. Computer Services Canada Ltd. (CSC) - MANAGE;
2. International Business Machines (IBM) - IMS
3. Multiple Access Computer Group (MA) - DRS
4. Canadian General Elecyric (CGE) - DMS II; and
5. Boeing Computer Service Co. (BCS) - INQUIRE.

The summary of the evaluation results is shown in Table 17, with the detailed evaluation of each system presented in Appendix 8.3.

Table 17. Summary of the data base management systems evaluation results.

Criteria	Weight	Maximum Score	BCS Rank	BCS Score	CGE Rank	CGE Score	MA Rank	MA Score	IBM Rank	IBM Score	CSC Rank	CSC Score
Needs												
Security	10	50	1.0	10.0	1.0	10.0	1.0	10.0	3.0	30.0	4.0	40.0
Inquiry	10	50	1.5	15.0	1.5	15.0	2.0	20.0	2.0	20.0	3.0	30.0
Update Maintenance	9	45	1.0	9.0	1.0	9.0	1.0	9.0	3.0	27.0	3.0	27.0
Audit Trail	6	30	0.0	0.0	1.5	9.0	.5	3.0	2.0	12.0	2.0	12.0
Logical, Arithmetic and Sort Facility	8	40	1.0	8.0	1.0	8.0	2.0	16.0	2.0	16.0	2.0	16.0
Report Generation	8	40	0.5	4.0	1.0	8.0	1.0	8.0	2.5	20.0	3.0	24.0
Integrity	6	30	0.0	0.0	0.5	3.0	1.5	9.0	2.0	12.0	2.0	12.0
Recoverability	6	30	0.0	0.0	1.0	6.0	0.5	3.0	1.5	9.0	3.0	18.0
Total Needs	63	315	5.0	46.0	8.5	68.0	9.5	78.0	18.0	146.0	22.0	179.0
Wants												
Service Bureau Cooperation/Support	5	25	1.0	5.0	1.0	5.0	3.0	15.0	1.0	5.0	4.0	20.0
File Structure	5	25	0.0	0.0	1.0	5.0	1.0	5.0	2.0	10.0	3.0	15.0
Record Formats	5	25	1.0	5.0	2.0	10.0	1.0	5.0	3.0	15.0	4.0	20.0
Data Formats	5	25	2.0	10.0	1.0	5.0	2.0	10.0	3.5	17.5	3.5	17.5
Program Language Interface	3	15	3.5	10.5	1.0	3.0	2.0	6.0	2.5	7.5	3.5	10.5
Total Wants	23	115	7.5	30.5	6.0	28.0	9.0	41.0	12.0	55.0	18.0	83.0
Total Score	86	430	12.5	76.5	14.5	96.0	18.5	119.0	30.0	201.0	40.0	262.0

6. SUMMARY

An inventory was conducted comprising all available chemical and physical characteristics, geographic location, and amount of withdrawals from and contributions to the water system (surface and groundwater) in the AOSERP study area. Data obtained from government agencies and companies operating in the study area are reported in summary tables.

A streamflow balance was conducted on the Athabasca River between Fort McMurray and Embarras. Within the reach, water use and effluent discharge requirements associated with oil sands development were put into perspective with the mean and minimum flows in the Athabasca River. Flow contributions associated with the tributary areas were also identified. The present and proposed net water requirements represent approximately 7% of the one in 20-year return minimum daily flow of the Athabasca River at Embarras.

A review of available data base management systems appropriate for use by Alberta Environment was conducted. The review comprised the following five companies and their respective systems:

1. Computer Sciences Canada Ltd. - MANAGE;
2. International Business Machines - IMS
3. Multiple Access Computer Group - DRS;
4. Canadian General Electric - DMS II; and
5. Boeing Computer Services Co. - INQUIRE.

Based on an objective evaluation, Computer Sciences Canada Ltd. and their MANAGE data base management system ranked the highest, capable of providing the needs of Alberta Environment.

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8. APPENDIX

8.1 LITERATURE REVIEW

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8.2 TERMINOLOGY

The following are definitions of terms and their synonyms currently used by different manufacturers of data base management systems:

1. Data Element (Data Item, Field): a data element is the smallest unit of information that can be defined and manipulated. Associated with each data element is a name, type, length, and value.
2. Segment (Member Record, Record-type, Group): a segment consists of one or more data elements which are logically related to each other. Associated with a segment is a name and length which is related to the data elements in the segment. A segment may be defined to contain more than one occurrence of a given data element. For every data element, which occurs only once, each value yields another segment.
3. Record (Logical Record): a record consists of one or more data elements and/or one or more segments. Associated with a record is a name and length which is related to the data elements and segments in the record. A record may be defined to contain multiple occurrences

of data elements and/or segments. Each value of a data element which occurs only once and for each segment another record is defined.

4. File: a file is a collection of one or more records. The existence of at least one record defines the file. Associated with the file is a name that is related to the records in the file and logical structure. Three types of structures are defined for files: network, hierarchic; and sequential. Both the hierarchic and sequential file structures are degenerate networks.
5. Network File Structure: a network file structure is defined to be a file in which a record may be pointed to by one or more other records and which in turn may point to one or more other records.
6. Hierarchic (Tree) File Structure: a hierarchic file structure is one in which a record may be pointed to by only one other record, but may point to one or more other records.
7. Sequential (Serial) File Structure: a sequential file structure is one in which a record may be pointed to by one and only one other record and may point to one and only one other record.
8. Data Base: a data base consists of one or more files which may or may not be related. In the simplest case, one file is analogous to a data base. In the case of several files within the data base, known interfile relationships may or may not exist; data elements or segments may be defined as a member of more than one file. This enables information related to more than one file to be stored in only one data element or segment within the data base, and all other files requiring this information may obtain it by means of inter-file relationships.

9. Transaction: a transaction is any command or request that would normally result in an access to a data base for retrieval or modification of a record, segment, or element.
10. Interrogate, Inquiry, Query: these terms are usually used to describe a request to the data base such as search, display, or select which does not result in any physical change to the data base.
11. Update: an update is a command or request such as add, delete, insert, or modify which usually results in a change or alteration to the data base at the record, segment, or data element level.
12. Maintenance: maintenance is used to describe any function that interacts with the data base at the file level. For example: define, create, save, etc.
13. Set: a combination of two data files linked together to establish an owner/member relationship.
14. Schema: the schema is the largest collection of data definable by a data base administrator. It defines the record types included in the schema, the data elements included in each record type, the structural properties of each data element, and the sets of record type pairs included in the schema.
15. Subschema: is a named collection of record types linked together into sets from which structures are defined.

8.3 DETAILED EVALUATION OF DATA BASE MANAGEMENT SYSTEMS

A detailed evaluation, according to the criteria outlined in Section 5.4, is provided of the following candidate systems and the respective companies.

8.3.1 International Business Machines (IBM) - Informative Management Systems/VS (IMS)

8.3.1.1 Security. IMS provides the security features outlined in the Evaluation Criteria as standard features. In addition, terminal and other user passwords are provided for on-line environments.

8.3.1.2 Audit trails. IMS provides extensive logging of transactions plus utilities to analyze the data. This facility may be used for audit/recovery/restart and security monitoring purposes. These facilities may also be used for data base transaction analysis for tuning, accounting, etc.

8.3.1.3 Data base concepts

1. File Structures: hierarchial and sequential file structures are allowed dependent on the specific application, a network file structure may also be defined within the structure of IMS;
2. Record Format: IMS is designed to provide all the attributes outlined in the evaluation criteria, under record formats; and
3. Data Element Format: fixed and variable length data elements are permitted. Available data types are hexadecimal, packed decimal, binary full-word or half-word, alphanumeric, or a combination of types.

8.3.1.4 Data base language (DBL). IMS files are accessed through an access language called Data Language/1 (DL/1). DL/1 call statements are used in COBOL, PL/1, or Assembler Language Programs. Alternatively, higher level packages may be used to improve application programming productivity or allow data base accesses to the inexperienced DP user. Example of such packages are ADF and GIS. Some of the facilities provided are as follows:

1. Inquiry Facility: GIS would be best suited for this requirement. GIS provides an inquiry facility for interrogating the data base. Up to 16 files may be processed simultaneously;

2. Update and Maintenance Facility: the requirements outlined in this section are all provided by DL/1. Data checking and editing would be provided within the logic of the specific application program; and
3. Logical, Arithmetic, and Sort Facility: these attributes are best handled in the logic of the application program.

8.3.1.5 Report generation. GIS would accommodate this requirement. Extensive output formating and headings are defined in file definition and demand reports are easily generated. Summary information of data elements can be produced in reports such as totals, sub-totals, averages, etc.

8.3.1.6 Programming language interface. DL/1 data base access is made from within a high-level programming language program. IMS file accesses can not be made without using DL/1.

8.3.1.7 Systems stability

1. Integrity: the main design objective of the IMS is data base integrity; IMS provides the following standard features:

   Logging: IMS has extensive logging features and utilities which allow for data base records as they existed before the transaction, after the transaction, and the transaction itself, plus periodic check point records facilitating the recovery exercise. In addition, all log-file records are written and verified before the change is made to the data base, thus guarding data base integrity.

   Dynamic Backout: In addition to logging, IMS maintains records of the transactions from synch-point for an individual application. Then if an application program encounters problems, dynamic backout is invoked to backout transactions to a synch-point, re-apply the successful transactions, and issue appropriate message regarding the failing transactions.

2. Recoverability: as described briefly above, there are a number of automatic and operator-invoked recovery features in IMS to facilitate this process.

8.3.1.8 Service bureau co-operation and support. IBM gave very little co-operation and support in the evaluation of their DBMS. At first, they indicated an unwillingness to participate in the study. However, they finally provided six techncial manuals with a two-page covering letter. Consequently, an exorbitant amount of time was spent extracting the relevant information from the manuals.

8.3.2 Multiple Access Comuter Group - Data Retrieval System (DRS)

8.3.2.1 Security. Through the use of passwords, entire data bases, certain records, certain fields, and even certain commands may be restricted to selected users only. Passwords may be altered, deleted, or new ones introduced at any time.

8.3.2.2 Audit trails. There is not automatic facility for DRS to log transactions. This must be achieved by writing a procedure within the JCL. DRS does however provide the user with transaction statistics on the data base files.

8.3.2.3 Data base concepts

1. File Structures: DRS employs an associative structure, providing specific capabilities in defining network, hierarchic, and sequential data base.
2. Record Formats: records within DRS comprise fields defined individually as fixed in length or variable and allows for multiple occurrences of fields.

Different types of records are inter-related into an associative structure which provides "one too many" and "many too one" relationships by linkage fields embedded in records containing pointers between related records. This, however, would mean that when new records are added to the data base, the data base would have to be recreated entirely.

3. Data Element Formats: DRS field structure provides for both fixed and variable length and permits test, integer, real, and date types.

8.3.2.4 Data base language (DBL)

1. Inquiry Facility: there are three basic commands which allow the user to retrieve data. The select command is used to select from a data base a subset of data meeting the criteria of a simple to sophisticated logical statement for the qualification of records. With the arrangement command, the user can organize a selected subset to order the values present in one or more categories of the subset. The list command provides for outputting all or parts of the selected and arranged subset; this listing function can be directed to the interactive terminal or to various other sequential devices. For the more technical user, DRS offers many additional commands. New fields can be defined in terms of an arithmetic or logical expressions involving currently stored fields. A count of the number of records which have the same values in a specified field can be obtained. Headings can be added or changed interactively as well as prestored.

2. Update and Maintenance Facility: the data base generator (DBG) is a facility which DRS uses to define and create data bases. The DBG requires a simple command stream of one or more master records and an additional record per data base field. From this input the DBG generates input for the creation of files that go to make up a DRS data base. This same facility is used to maintain data base definitions after initial creation.
   The system permits the input, modification or deletion of records or data base elements either interactively or in a batch mode from either sequential or direct access devices. A wide range of error checking logic is available including range checks, minimum and maximum length, and pattern matching.
3. Logical, Arithmetic, and Sort Facility: DRS inquiry language has arithmetic and full boolean logic capabilities for record selection and data base inquiries. It also has a facility to sort selected subsets of data according to data element values.

8.3.2.5 Report generation. Report generation is very versatile within DRS. It performs page formating by itself or with the users direction as to number of lines per record, page breaks, identification, justification, and headings. The reports can be generated at low speed terminals or brought out on high speed line printer. In addition, DRS will also generate microfiche of photocomposition tapes, punch cards, or a source tape. A powerful report-writer language provides complete program logic facility with full computational capabilities.

8.3.2.6 Programming language interface. A link module can be used to tie in any programs written in COBOL or FORTRAN to the data base within the interactive query language. Thus providing a route into DRS to enable data flow in either direction for special calculations or manipulations.

Link modules may be guite comparable in power with facilities capable of the following: (1) link out to be a closed computation or plot routine in back; (2) access of data base; (3) modify data base; and (4) add records to a data base.

This feature is well suited to those applications which require calculation routines which in many other packages would exceed the limits of the natural language.

8.3.2.7 System stability:

1. Integrity: data integrity in DRS is insured through extensive dynamic error checking facilities that are involved automatically by DRS on the basis of specifications entered at definition time. Records containing errors are logged by DRS and available to the user by his execution of a List Errors or Select Errors Commands; and
2. Recoverability: all disk files on the multiple access system are automatically backed up to magnetic tape once daily. Thus, if an unrecoverable problem does arise with a file, it could be restored from the previous days backup tape. However, any modifications to the data base for the current day would have to be re-entered.

The multiple access NOS operating system has self-diagnosing error detecting capabilities for software and in many instances recovery is automatic; however, if a hardware failure occurs, this is not always possible.

8.3.2.8 Service bureau co-operation and support. Multiple Access Computer Group provided favourable co-operation and support in the evaluation of their DRS. In addition, technical literature, detailing corporate qualification, and operating system breakdown were also provided.

8.3.3 Boeing Computer Services Company - INQUIRE, MAINSTREAM, TSO/CTS

8.3.3.1 Security. To prevent unauthorized access or alterations to data bases, INQUIRE includes a privacy mechanism based on pass-words. In addition to the security built into MAINSTREAM-TSO and MAINSTREAM-CTS, data can be restricted at the system (application) level, data base level, or field level. Based upon their pass-words, for example, some users can be authorized to use retrieval or maintenance commands while others can be restricted to retrieval only.

8.3.3.2 Audit trails. Once data bases are created, utility programs are available for tasks such as data base, dump and restore, or printing of key word lists and multi-columnar formats. From the technical literature provided by a Boeing Computer Services Company, their INQUIRE data base programming system appears to less than adequate audit trail.

8.3.3.3 Data base concepts

1. File Structures: INQUIRE uses a sequential file structure as its base;
2. Record Formats: fields may be subdivided (redefined) and can contain multiple (repeating) values with either a fixed or a varying number of repetitions; and
3. Data Element Format: data elements may be defined as fixed or varying length character or numeric (packed, binary, or display).

8.3.3.4 Data base language (DBL)

1. Inquiry Facility: inquiries free format language implements the functions of information retrieval and report generation, data base maintenance, and administrative control processing via an English-like syntax. The same syntax is used in both batch and interactive application. Language queries can retrieve data by either a direct (key word) or seqential (field value condition) searching of data bases or combination of both. Selection criteria are connected by the Boolean operators and, or, and not, and link.
2. Update and Maintenance Facility: the loader system actually creates the data base, performs data validation and editing, and provides for bulk additions. Rejected items are placed on separate file for examination, correction, and resubmission by the user. The loader system is optimized for creation of bulk additions to the file.

3. Logical, Arithmetic, and Sort Facility: the user language allows full data manipulation and report generation facilities for the retrieved data. Standard formating, editing, and titling operations are combined with operations such as sorting, paging, and sub-totalling for data retrieved from the data base and computed or defined in the query.

8.3.3.5 Report generation. As mentioned in the preceeding, the user language may be utilized for a conditional printing of data, text insertion, table lookup, cross-tabulation, bar charting, totalling, and sub-totalling.

8.3.3.6 Programming language interface. A host procedural language interface allows programs written in COBOL, PL/1, FORTRAN, or assembler to access and update INQUIRE data bases. Retrieval and maintenance are envoked using standard call statements in the programming language chosen. No precomplier is necessary.

8.3.3.7 System stability. Unfortunately, Boeing Computer Services Company Limited was unable to provide adequate information to properly investigate this area.

8.3.3.8 Service bureau co-operation and support. Boeing Computer Services Company Limited was most receptive in providing information for this study. However, the information they provided consisted of a four page sales brochure from which it was difficult to extract pertinent information.

8.3.4 Canadian General Electric Company Limited - Data Management System II (DMS II)

8.3.4.1 Security. Using features of the Mark III Operating System which is installed in Canadian General Electirc Company Limited (CGE), security is provided for unauthorized access at file, record, and data item levels.

8.3.4.2 Audit trails. Audit trails are available in DMS II using the deferred mode of incremental update.

8.3.4.3 Data base concepts

1. File Structures: the DBMS allows for network, hierarchic, and sequential file structure;
2. Record Format: record formats include fixed and variable length records with multiple occurrences of fields. The DBMS provides you with logical record capabilities; and
3. Data Element Format: data items may be fixed or variable; several common data types are available.

8.3.4.4 Data base language (DBL)

1. Inquiry Facility: data retrieval can be made using a simple English-like language. The DBL is user oriented with error messages which are easily understood. Data retrieval can be real time or deferred;
2. Update and Maintenance Facility: during updates, automatic checking of each piece of datum against its type, declaration, and size, as specified in either the update module or the data base definition file, takes place; and

3. Logical, Arithmetic, and Sort Facility: users can easily update the DB, Logical, Arithmetic, and Sort functions.

8.3.4.5 Report generation. The DMS language provides for report generation including total, sub-totals, and averages, using the tabulate verb; there are default heavy and detailed levels of macro-instruction.

8.3.4.6 Programming language interface. The data base is stored in a hysam type file, which the user can access with both FORTRAN and DMS II. Interface exists between TABOL (a matrix language with rows and columns), user-written sub-routines, and the HISAM data file, which contains the DMS II data base.

8.3.4.7 System stability

1. Integrity: DMS II has few error detection devices within its natural language; however, CGE does provide complete backup for the data base on a 24-hour basis; and
2. Recoverability: in case of system interrupts, automatic recovery and restart are available under CGE operating system.

8.3.4.8 Service bureau co-operation and supports. From the outset, CGE appeared to be very co-operative and eager in providing information as requested; however, the information received was incomplete and further investigation was required.

8.3.5 Computer Sciences Canada Limited - MANAGE Data Base Language

8.3.5.1 Security. Computer Sciences Canada Limited (CSC) security begins with the procedure to sign on the system. A customer has an assigned users identification plus a six character password that can be changed by the customer was well. A project code may also be a necessary part of the sign-on. This, however, is optional. Security levels with the actual data base are as follows:
(1) a MANAGE data base administrator implements the data base security by adding user access control specifications to the schema;
(2) the data base administrator (DBA) can add both data validation or access control specifications or a combination of both; and
(3) each MANAGE schema object file includes a matrix that controls the access to each element, record type, and subschema associated with that schema.

Therefore, MANAGE provides access restriction capabilities at four levels: the schema, subschema, record type, and element (group or sub-element).

Other security features include the capabilities of restricting access to data base element by data element value and the ability through the audit trail feature to log all attempted breaches of the data base security.

8.3.5.2 Audit trails. Different facets of the audit trail feature are provided by two commands, the "log" and "for audit". The "log" command posts changes to the data base in a real time to the system log. Each transaction successfully posted causes the data base record to be written on the system log. A feature is also available which enables the user to determine whether an update should be rolled back or declared to be final. In addition,

the feature enables automatic transaction roll-back if the task is unable to be completed, either due to a task failure itself or a system crash or terminal disconnect during the task.

The "for audit" feature logs all attempted breaches of security.

8.3.5.3 Data Base Concepts

1. File Structure: MANAGE is based on an independent logical file concept and can therefore define the following: flat (relational file structure), hierarchial structure, and network structures.
   In deterimining the data to be stored, MANAGE uses a definition language (DDL) that follows codasyl guidelines. Within the DDL, one define the components of each record type and a relationship between the records (schema). A second component is available (sub-schema) to define smaller logical sub-sets of the data base and to also define interrogation language interface requirements. A utility processor, IDBDEF, is used to generate the schema and sub-schema object files.
2. Record Formats: MANAGE record format allows for the definition of fixed length records and variable length records.
   With both record formats it is possible to define multiple occurring fields. For fixed length records, this would imply the use of a fixed number of occurrences (array); for variable length records, it would imply a variable number of occurrences of the field (repeating element). For repeating elements, disk space is dynamically allocated; that is, only the storage required by existing occurrences of the element is used.

A logical record capability is provided for by the use of structures, which are a collection of physical record types linked together. The linkage between records is provided by equal valued elements in an owner and member record. The structures are constructed in such a way as to provide a non-ambiguous path through a structure. Both one to one and one to many relationships between records are possible. Data loading may be performed on a record-type by record-type basis. This is often useful as member (child) records may be loaded before the owner (parent) record is loaded. Thus, data may be loaded as it becomes available.

It should also be noted that the Computer Sciences teleprocessing system supports variable length records. This operating system feature, combined with the storage optimization technique used by MANAGE, makes very efficient use of disk storage. The user does not have to be concerned with aligning data elements on full-word boundaries.

3. Data Element Format: both fixed length and variable length records are permitted. Data element types available are: (a) Character - both fixed and variable length; (b) Binary - with or without a scale factor; (c) Decimal - with or without a scale factor; (d) Float - single precision floating point; (e) Group - grouped element containing sub-elements which may be of any of the element types listed here; the group element is a character-type element; and (f) Date - date element stored internally in binary form; for display purposes, it is converted into either an eight or 10 character format.

For each data base, one element must be defined as a primary key. This element must have the unique value in that file. Other elements in the data base file may be defined as being alternate keys. Alternate and primary keys have inverted files associated with them which allow for direct retrieval of data base records and elements through the use of these elements.

8.3.5.4 Data Base Language. The following four languages are available to interface with MANAGE data base: (1) Data Definition Language (DDL); (2) Natural Language; (3) Report Writer and Inquiry Language (QUERY); and (4) Program Language Interface (PLI). The DDL is capable of both defining and modifying the data base structure at any level. The natural language may be used to both updated and report on the data base as may QUERY. PLI will be described in more detail in Section 8.3.5.6.

1. Inquiry Facility: the principle inquiry facility available to interrogate the data base is a report writer feature called QUERY. QUERY is an English-like language. QUERY is capable of producing sophisticated reports through the ability to change the column headings and elements, for example. (A rename capability exists, whereby an element may be referred to by name other than that in the data base description). Other facilities exist for the neat and easy formating of reports such as line spacing, titles, etc. The language is both free-form and procedural in that checks are made against the instructions as they are entered. Diagnostic messages are issued if any errors are made when an inquiry is entered. Inquiries may be intuitively

made. The only knowledge required to make an inquiry would be a knowledge of the data base element names. Even if these are forgotten, a sanctioned user could obtain the element names through the use of the IDBD utility. In addition, the natural language, which is also free-form and procedural, may be used to interrogate the data base. This language is similar to BASIC and easily used. It is, however, only a a supplementary means of inquiry.

2. Update and Maintenance Facility: as with the inquiry facility, various aspects of this function may be performed by all four languages. The DDL has the following capabilities: (a) defining and creating a data base schema. This implies the definition and creation of the data base files, associated secondary key files, sets of linked files, and a definition of those links, files being linked by data value; (b) defining and creating a subschema. This implies the definition and reaction of a sub-set of the data base, which may be used for both updating and reporting purposes. The DDL has the ability to select elements from each data base file for inclusion in the sub-schema and to arrange groups of such files in structures linked together by the links defined in the schema definition; (c) modify a schema definition and any part of the schema definition (elements, sets) through the use of IDBDEF utility. This may be the addition of a new record type to the data base, an addition of new element to a data base file, an addition of a new set; or a change in the definition of an existing record, element, or set; or deletion of a record, element or set; (d) put security, data validation,

transaction log, and audit trail features in place on either a new or an existing data base; and (e) modify a data base sub-schema through the addition, deletion, or modification of elements selected from files and the associated structures. Structures may also be added, replaced or deleted.

The natural language may be used to add, delete, change, or update any record in any MANAGE data base file. It is a procedural programming language; has comprehensive error diagnostics, extensive character handling, and arithmetic capabilities. Therefore, it is easily used for the maintenance of a data base.

The QUERY report writer language also has data base maintenance capabilities. It may add, delete, or change data base records through the use of the add record, or delete record, and change directives within the QUERY language. Used with the logical and arithmetic feature, these provide a useful data base maintenance tool. Data elements may be added, changed, or deleted by use of the change directed for additions and changes, and the delete directive for deletions.

A new data base record type may be defined and created by use of the build directive.

3. Logical, Arithmetric and Sort Facility: logical, arithmetic, and sort features are available in the QUERY report writer. The "if" and "where" directives may be used to select records or elements with extremely complex logical criteria. Boolean algebra is used in evaluating the selection criteria. Both the "if" and "where" clauses may be used in connection with both the report and maintenance facilities

of QUERY. Arithmetic capabilities include the ability to perform addition, subtraction, division, and multiplication. Variables may also be defined as the sum of several data base elements.

8.3.5.5 Report Generation. Reports may be quickly and easily generated using the Query language. As stated in Section 8.3.5.4, QUERY contains a variety of functions which may be categorized as follows: (1) data base updating and maintenance; (2) logical arithmetic, and sort facilities; (3) report default modifying and control statements; (4) print facility; (5) control commands; and (6) text area commands.

8.3.5.6 Programming Language Interface. The data base is accessable through a programming language interface (PLI) which is accessable through FORTRAN and COBOL. A data base may be accessed or updated at the subschema, record, and element levels by the PLI. Once the record or subschema is available, elements and records may be added, changed, or deleted by the use of routines provided by the PLI. Both ancestor and descendent data base records of a current record may be retrieved by a simple PLI call. These routines are called in the same manner as a normal FORTRAN or COBOL routine. Reports and inquiries may be produced by a combination of the FORTRAN or COBOL program using PLI routines.

8.3.5.7 System Stability

1. Integrity: by using the "log" and "for audit" features the data base integrity may be maintained. The roll-back feature described in Section 8.3.5.2 will automatically roll back the data base to any previous state if the task should fail for an external reason. Element value protection is provided by means of the data validation clauses available through the DDL.

Error diagnostics are produced if these values are not complied with. The security features described in Section 8.3.5.1 help maintain data integrity by restricting access to the data base. The "log after images" statement in DDL causes all records updated to be posted to the computer system log. Data base files may also be backed up to either tape or disk by using the IDBUTL utility.

2. Recoverability: the facility which provides recoverability of the data base besides, those which are available through the Computer Sciences Canada Limited GPS sub-system, are as follows. By use of the "log" facility, data base records are posted to the system log tape. If the system crashes or the task performing the update fails, then all transactions successfully completed will be posted to the system log. However, the data base will not be computed; that is, the updated version of the data base files will not be posted. The log directive causes the automatic backup of all data based files successfully updated. Therefore, with all transactions successfully performed on a data base stored in the system log, even if the task eventually fails, it may be restarted from the point of failure, after the appropriate files have been recovered from the log.

8.3.5.8 Service Bureau Co-operation and Support. Computer Sciences Canada Limited provided a detailed, concise report, emphasizing areas outlined in the evaluation criteria. Their co-operation and support was excellent in providing information in appraising their system.

9. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "A Feasibility Study"
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32.		AOSERP Third Annual Report, 1977-78
33.	TF 1.2	Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34.	HY 2.4	Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35.	AF 4.9.1	The Effects of Sedimentation on the Aquatic Biota
36.	AF 4.8.1	Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I
37.	HE 2.2.2	Community Studies: Fort McMurray, Anzac, Fort MacKay
38.	VE 7.1.1	Techniques for the Control of Small Mammals: A Review
39.	ME 1.0	The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40.	WS 3.3	Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
41.	AF 3.5.1	Acute and Chronic Toxicity of Vanadium to Fish
42.	TF 1.1.4	Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
43.	TF 6.1	A Socioeconomic Evaluation of the Recreational Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume I: Summary and Conclusions
44.	VE 3.1	Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45.	VE 3.3	Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
46.	VE 3.4	Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978.
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48.	HG 1.1	Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review on Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53.	HY 3.1.2	Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54.	WS 2.3	A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55.	HY 2.6	Microbial Populations in the Athabasca River
56.	AF 3.2.1	The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57.	LS 2.3.1	Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58.	AF 2.0.2	Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59.	TF 3.1	Semi-Aquatic Mammals: Annotated Bibliography
60.	WS 1.1.1	Synthesis of Surface Water Hydrology
61.	AF 4.5.2	An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62.	TF 5.1	Amphibians and Reptiles in the AOSERP Study Area
63.	ME 3.8.3	Analysis of AOSERP Plume Sigma Data
64.	LS 21.6.1	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.	LS 21.6.2	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.	AS 4.3.2	An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67.	WS 1.3.2	Aquatic Biological Investigations of the Muskeg River Watershed
68.	AS 1.5.3 AS 3.5.2	Air System Summer Field Study in the AOSERP Study Area, June 1977
69.	HS 40.1	Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70.	LS 28.1.2	An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71.	HY 2.2	Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72.	LS 7.1.2	The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73.	LS 23.2	Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
74.	AS 4.5	Air Quality Modelling and User Needs
75.	WS 1.3.4	Interim Report on a Comparative Study of Benthic Algal Primary Productivity in the AOSERP Study Area
76.	AF 4.5.1	An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
77.	HS 20.1	Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.
78.	LS 22.1.1	Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta

79.	AF 3.6.1	The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish.
80.	HS 10.2 & HS 10.1	History of the Athabasca Oil Sands Region, 1980 to 1960's. Volumes I and II.
81.	LS 22.1.2	Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta.
82.	LS 22.2	Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area.
83.	LS 22.2	The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area.
84.	WS 1.6.1	Investigations of the Spring Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray; Volume I.
85.	HY 2.5	An intensive Surface Water Quality Study of the Muskeg River Watershed. Volume I: Water Chemistry.
86.	AS 3.7	An Observational Study of Fog in the AOSERP Study Area.
87.	WS 2.2	Hydrogeological Investigation of Muskeg River Basin, Alberta
88.	AF 2.0.1	Ecological Studies of the Aquatic Invertebrates of the Alberta Oil Sands Environmental Research Program Study Area of Northeastern Alberta
89.	AF 4.3.2	Fishery Resources of the Athabasca River Downstream of Fort McMurray, Alberta. Volume 1
90.	AS 3.2	A Wintertime Investigation of the Deposition of Pollutants around an Isolated Power Plant in Northern Alberta
91.	LS 5.2	Characterization of Stored Peat in the Alberta Oil Sands Area

These reports are not available upon request. For further information about availability and location of depositories, please contact:

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