ATHABASCA RIVER BASIN

WATER USE ASSESSMENT

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PREPARED FOR

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ATHABASCA RIVER BASIN PLANNER

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SYNOPSIS

The Athabasca River Basin contains valuable resources including timber, coal, petroleum and natural gas, and oil sands. A variety of intensive development activities are taking place and the use of water in these activities is important. In order to provide the Athabasca River Basin Planner with water use data (allocation, withdrawals, and consumption), this report identifies current and potential future water uses in the basin.

The Athabasca River alone is an important source for many users. It is estimated that nearly 76 percent of all water used in the basin in 1981 was obtained from the river, 22 percent from major tributaries and other surface sources, and the remaining 2 percent from groundwater sources.

The smallest water using sector in the basin is municipal use, amounting to 12.40 x $10^6 m^3$ or 6 percent of total withdrawals in 1981. Consumptive uses amounted to 2.48 x $10^6 m^3$ or 3 percent of total consumption.

In the future, it is anticipated that municipal water use will increase as a result of population growth associated with further resource developments. Forecasts indicate that withdrawals for the sector will rise by 149 percent to 30.91 x $10^6 m^3$ or 3 percent of total, and consumption to 6.18 x $10^6 m^3$ by the year 2001, at which time municipal withdrawals will rank second after industrial withdrawals.

The second largest water using sector currently in the basin is agricultural water use. In 1981, withdrawals and consumption were 17.71 x $10^6 m^3$, comprising 9 percent of total withdrawals and 25 percent of total consumption. Water use for the sector is expected to rise by 53 percent to 27.02 x $10^6 m^3$ by 2001, when it will comprise 3 percent of total withdrawals and 11 percent of total consumption.

Water use in the basin is dominated by the industrial sector. Industries accounted for an estimated total 178.16 x $10^6 m^3$ or 85 percent of all water withdrawn in 1981. The sector's total consumptive water use in 1981 amounted to an estimated 51.91 x $10^6 m^3$ or 72 percent of total basin consumption. The two oil sands plants (Suncor and Syncrude) account for the major portion of industrial water use.

A variety of industrial activities have been identified in the basin for potential development based upon natural resource availability. Beyond the year 2001, industrial water withdrawals are forecasted to rise to 1 004.15 x $10^6 m^3$ and consumption to 202.40 x $10^6 m^3$ if all currently identified industrial projects are developed as predicted.

Total water withdrawals in the Athabasca River Basin are forecasted to rise from 208.27 x $10^6 m^3$ in 1981 to 1 062.08 x $10^6 m^3$ beyond the year 2001. Total water consumption is forecasted to rise from 72.10 x $10^6 m^3$ in 1981 to 235.60 x $10^6 m^3$ over the same period.

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INTRODUCTION

Subject

The Athabasca River Basin, a part of the MacKenzie River drainage system, has a total area approaching 161 000 km^2 (62 150 sq.mi.), and about 144 700 km^2 (55 900 sq.mi.) or 90 percent of the drainage area is located in Alberta.* Figure 1 shows the location of the basin in the province, and a more detailed map is presented on Figure 2.

The Athabasca River, originating in the Athabasca Glacier of the Rocky Mountain Columbia Icefields, winds its way northeast for about 1 280 km (800 mi.). Along its course to Lake Athabasca, the river is fed by several major tributaries including the Berland, McLeod, Pembina, Lesser Slave, La Biche, and Clearwater Rivers (see Figure 2).

The Athabasca River Basin is subject to intensive resource development activities including forestry-related operations, coal mining and processing operations in the foothills and mountain regions, oil and gas recovery and processing activities, and oil sands extraction and processing operations. Water plays an important role in these activities and particularly in potential developments for the coal and oil sands resources. Growth of population, economic activity, and potential resource-related industrial projects will increase the requirements for water.

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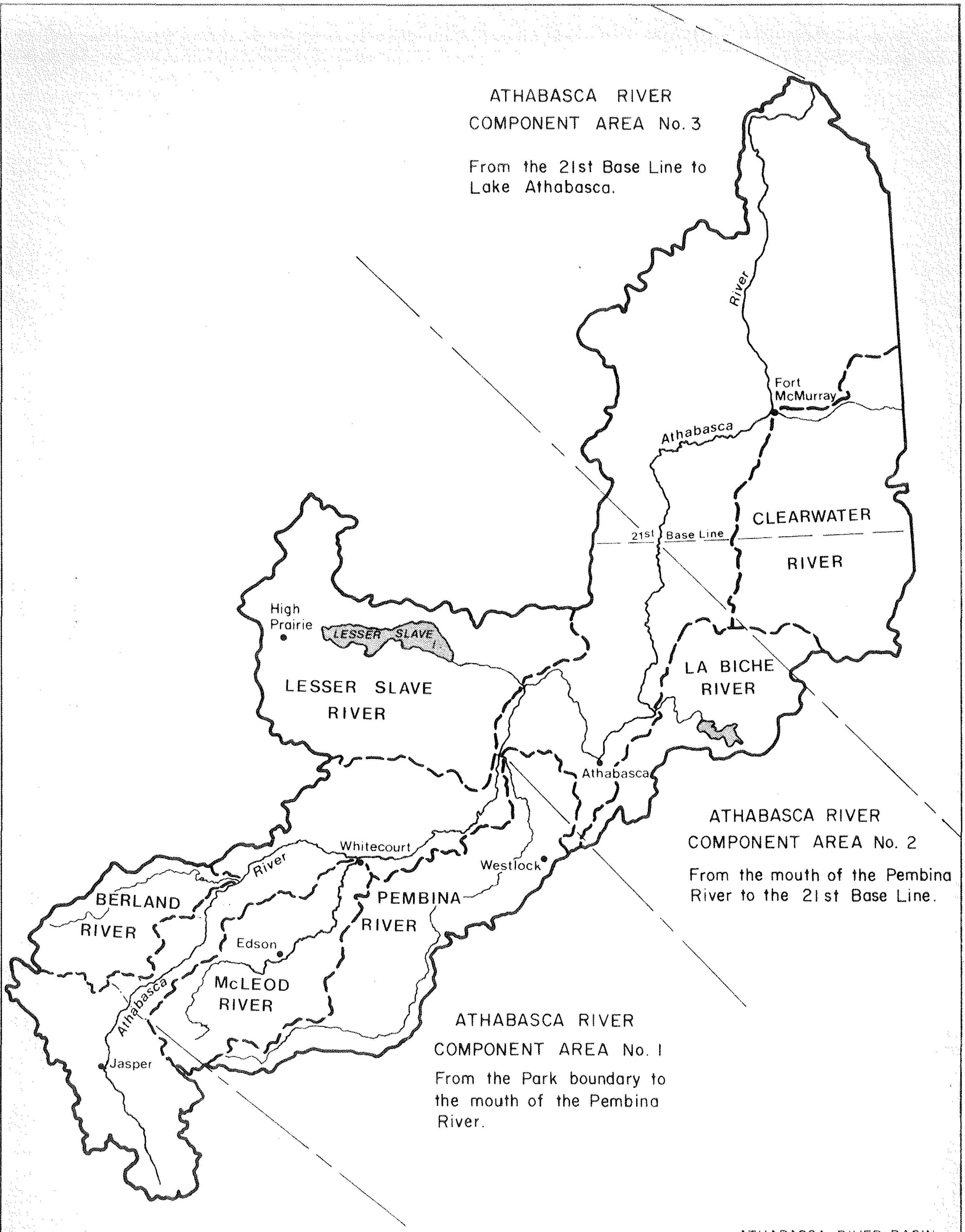
* Athabasca River Basin area obtained from Areas of Drainage Basins Within Alberta, by Technical Services Division, Hydrology Branch, Alberta Environment, January 1978.

ATHABASCA RIVER BASIN

KEY MAP

FIGURE 1



ATHABASCA RIVER BASIN

SUB-BASIN COMPONENT AREAS

FIGURE 2

Purpose

In view of limited information on the water resources in the basin, the Athabasca River Basin Planner is compiling data to formulate a plan for managing the water resources of the basin. In response to a request from the Basin Planner, the Water Use Section of the Planning Services Branch conducted a water use study. The purpose of the study was to assemble water use information for licensed allocations, withdrawals and consumptive water uses for municipal, agricultural and industrial purposes in the Athabasca River Basin, describing past and current patterns and estimating future water uses where possible. The results of that study are presented in this report.

Scope

The scope of the study was limited to compiling, reviewing and analyzing available water use data. The study's scope was further constrained by the reliability, age and accuracy of the data. The data are taken from various sources that documented the physical, sociological, economic and other aspects related to water uses in the basin.

The emphasis in this report is on the use of surface water resources. The basin has been divided into separate sub-basins and reaches along the Athabasca River, for which separate water use estimates were prepared (the Berland, McLeod, Pembina, Lesser Slave, La Biche and Clearwater sub-basins), and three reaches:

a) Athabasca 1 from the Jasper Park boundary to the mouth of the Pembina River;

b) Athabasca 2 from the mouth of the Pembina River to the 21st baseline;

c) Athabasca 3 from the 21st baseline to the mouth of the Athabasca River.

The basin's concentration of valuable natural resources present opportunities for many industrial activities and future developments, each of which has unique water use characteristics. Due to the wide variation in industrial water use, they were disaggregated according to resource types. Although it is generally difficult to forecast the type, size, timing, and extent of future industrial developments, some potential scenarios are presented. Only very approximate magnitudes of water use data associated with potential industrial projects are presented because of the indefinite extent of the natural resources, constantly changing technology, and the uncertainty regarding the economic feasibility of some future projects. Non-withdrawal water uses such as recreation, fish, waterfowl, and wildlife habitat maintenance, and water quality control were not covered. These aspects would have to be considered in the management plant as they could lead to potential conflicts among present and future withdrawal users.

MUNICIPAL WATER USE

Historical and Current

The Athabasca River Basin contains many natural resources and their development has given rise to a variety of types of communities, including the oil sands based City of Fort McMurray, the forest industry based Town of Hinton, the agricultural services centres such as Barrhead and Westlock, and the smaller villages such as Kinuso and Boyle. This range in community size, service and structure gives rise to a variety of municipal water use characteristics.

One of the main indicators of municipal water use is municipal population. According to the 1976 Census figures, the urban population in the basin was estimated at 52 075 (55% of the total) and the total basin population was close to 95 000 (see Table 1). By 1981, the urban population, as shown in Table 2, had increased to 75 645. The figures presented in Table 2 show that Fort McMurray, accounting for 40 percent of the urban population, is the largest community in the basin. The city's fast growth is primarily due to the development of the oil sands.

According to information provided by Water Rights (9)*, summarized in Table 3, there are 61 active municipal projects with allocations amounting to about 25 758.7 x $10^3 m^3$. Twenty-five projects are allocated a total of 23 486.4 x $10^3 m^3$ (91 percent of the total) from surface water sources, and 36 projects have a total allocation of 2 272.3 x $10^3 m^3$ (9 percent) from groundwater sources. The Athabasca River itself is a source for 6 communities having a total allocation of 9 621.1 x $10^3 m^3$

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* Numbers in parentheses indicate the reference number as listed in the Bibliography.

TABLE 1

POPULATION - ATHABASCA RIVER BASIN

YEAR	URBAN	RURAL	RESERVATIONS	TOTAL
1951	11 600	48 026	3 355	62 981
1956	14 933	49 320	3 629	67 882
1961	26 704	46 766	2 510	75 980
1966	32 582	45 988	2 300	80 870
1971	41 837	44 016	889	86 742
1976	52 075	42 248	630	94 953
1981	75 645	40 900	450	116 955
1986	91 200	39 500	410	131 110
1991	115 100	38 100	380	153 580
1996	143 500	36 700	380	180 580
2001	176 800	35 300	380	212 480

SOURCE: The 1951 to 1971 population figures were calculated from Statistics Canada Census data by townships.

NOTES:

1. The population figures for Jasper have been excluded in this study.

2. 1976 urban population figures from Statistics Canada Census data.

3. 1981 urban population figures are from Statistics Canada 1981 Census interim populations, and the 1981 rural and reserve populations are estimates.

4. The 1986 to 2001 estimates are based on the following relationships developed from historical data:

   Urban population $P_U = 1.23966 \times 10^{-3} Y^{4.08}$ ($r^2 = 0.987$)

   Rural population $P_R = 569406.79 - 226.54Y$ ($r^2 = 0.911$)

   Where Y in both equations is the year.

   Reserve population are from linear trend approximation based upon 1951 to 1976 data.

TABLE 2

URBAN POPULATION - INCORPORATED COMMUNITIES

ATHABASCA RIVER BASIN COMPONENTS

RIVER BASIN COMPONENT	COMMUNITY	1961	1971	1976	1981
Athabasca 1 (from Jasper National Park border to mouth of Pembina R.)	Hinton	3 529	4 911	6 731	8 174
	Whitecourt	1 054	3 202	3 878	5 450
	Swan Hills	643	1 376	2 012	2 442
	Fort Assiniboine	216	173	185	205
	Total	5 442	9 662	12 806	16 271
Athabasca 2 (from mouth of Pembina R. to 21st baseline)	Athabasca	1 487	1 765	1 759	1 707
Athabasca 3 (from 21st baseline to Lake Athabasca)	Fort McMurray	1 186	6 847	15 424	30 368
Berland	---	---	---	---	---
McLeod	Edson	3 198	3 818	4 038	5 726
Pembina	Mayerthorpe	663	1 036	1 018	1 455
	Sangudo	325	360	409	393
	Westlock	1 838	3 246	3 721	4 361
	Barrhead	2 286	2 803	2 944	3 694
	Evansburg	452	528	671	770
	Entwistle	411	353	380	454
	Wildwood	479	386	360	429
	Total	6 454	8 712	9 503	11 556
Lesser Slave	High Prairie	1 756	2 354	2 281	2 469
	Kinuso	323	267	305	283
	Slave Lake	468	2 052	3 561	4 409
	Total	2 547	4 673	6 147	7 161
La Biche	Boyle	346	460	576	626
	Plamondon	---	189	228	257
	Lac La Biche	1 314	1 791	1 954	1 973
	Total	1 660	2 440	2 758	2 856
Clearwater	---	---	---	---	---
BASIN TOTAL		21 974	37 917	52 435	75 645

SOURCE: Statistics Canada, Census data.
The 1981 figures are from Statistics Canada 1981 Census interim population counts.

TABLE 3

ACTIVE LICENCED PROJECTS - ATHABASCA RIVER BASIN

(by River Basin Component, Statutory Purpose and Source of Supply)

RIVER BASIN COMPONENT		STATUTORY PURPOSE																TOTAL	
		AGRICULTURAL		DIVERSION		DOMESTIC		INDUSTRIAL		IRRIGATION		MUNICIPAL		STORAGE		OTHER			
		P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q
Berland	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	12.3	1	12.3 S
	G	--	--	--	--	3	9.9	--	--	--	--	--	--	--	--	--	--	3	9.9 G
McLeod	S	--	--	24	--	7	159.0	19	5 575.6	1	24.7	2	4 808.7	--	--	3	18.5	56	10 586.5 S
	G	1	8.6	--	--	2	4.9	13	664.6	--	--	10	1 385.9	--	--	--	--	26	2 064.0 G
Pembina	S	--	--	68	--	45	171.4	7	1 369.8	19	689.2	4	1 653.5	15	9 319.0	6	13 791.1	164	26 994.1 S
	G	28	173.9	--	--	2	77.7	38	4 082.5	--	--	18	811.3	--	--	--	--	86	5 145.4 G
Lesser Slave	S	--	--	22	--	10	45.6	12	17 730.5	--	--	5	339.1	4	6 165.0	1	61.7	54	24 341.9 S
	G	--	--	--	--	1	6.2	--	--	--	--	--	--	--	--	--	--	1	6.2 G
La Biche	S	--	--	23	--	9	51.8	1	180.0	5	671.9	3	383.5	7	48.1	3	--	51	1 335.3 S
	G	2	7.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	7.4 G
Clear-water	S	--	--	6	--	1	1.2	5	643.6	--	--	1	36.9	1	--	2	--	16	681.7 S
	G	--	--	--	--	--	--	9	483.3	--	--	--	--	--	--	--	--	9	483.3 G
Athabasca #1	S	--	--	5	--	3	12.4	14	115 786.8	2	146.7	1	6 596.6	3	7.4	2	1.2	30	122 551.1 S
	G	--	--	--	--	5	27.1	4	81.6	--	--	7	49.3	--	--	--	--	16	158.0 G
#2	S	1	--	24	--	9	27.1	1	1 356.3	1	517.9	4	887.9	4	39.5	--	--	44	2 828.7 S
	G	--	--	--	--	--	--	--	--	--	--	1	25.8	--	--	--	--	1	25.8 G
#3	S	--	--	5	--	--	--	13	186 145.2	--	--	5	8 780.2	--	--	6	--	29	194 925.4 S
	G	--	--	--	--	--	--	5	99.6	--	--	--	--	--	--	--	--	5	99.6 G
SUB-TOTAL	S	1	--	177	--	84	468.5	72	328 787.8	28	2 050.4	25	23 486.4	34	15 579.0	24	13 884.8	445	384 256.9 S
	G	31	189.9	--	--	13	125.8	69	5 411.6	--	--	36	2 272.3	--	--	--	--	149	7 999.6 G
TOTAL		32	189.9	177	--	97	594.3	141	334 199.4	28	2 050.4	61	25 758.7	34	15 579.0	24	13 884.8	594	392 256.5

SOURCE: Alberta Environment, Water Rights Branch computer printout of active projects in the Athabasca River Basin, September 1981.

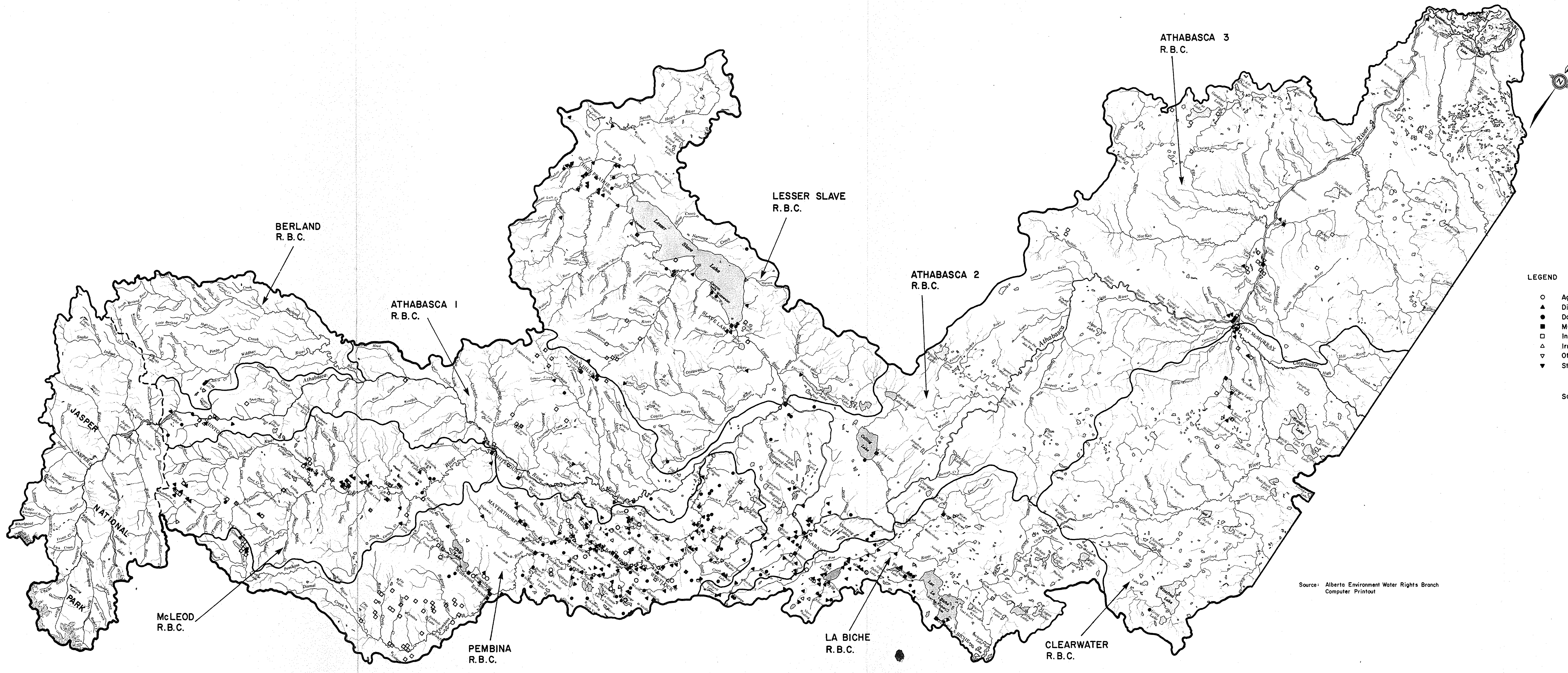
NOTES: Athabasca 1, 2, 3 components as described on Table 4 and Figure 2.

S - surface source
G - groundwater source
P - number of projects
Q - allocated quantity in thousands of cubic metres.

or 41 percent of the municipal surface water allocations. Fourteen projects in total, as shown by Table 4, are allocated quantities directly from the Athabasca River.

All the active projects in the basin, including municipal ones, their allocations and respective locations, are summarized in Table 3 and are plotted on Figure 3. Ninety-eight percent of all water allocations is from surface sources; 2 percent is obtained from groundwater sources. Although groundwater is not a major source, it is locally important. As Table 3 shows, groundwater is more heavily used (41 percent of total) in the Clearwater component, and to a lesser extent (16 percent of total) in both the McLeod and Pembina components. It is an insignficant source of supply in the other basin components.

Accurate current data and historical water use information for communities in the basin are not readily available. A review of water use in communities was conducted. Pertinent municipal planning and water supply assessment reports were consulted, and records of total annual withdrawals, including details of the water source were also obtained wherever possible. For communities with incomplete records, the missing data were constructed by imposing the trend of the per capita withdrawals from similar communities upon the missing years. This assumes that changes exhibited by the communities with data was representative of changes that occurred in other centres without data. This trend analysis technique was employed to reconstruct withdrawals for the missing years. Water use trends for the period 1971 to 1980



ATHABASCA RIVER BASIN

ACTIVE PROJECTS

BY STATUTORY PURPOSE

FIGURE 3

TABLE 4

ACTIVE LICENCED PROJECTS - ATHABASCA RIVER BASIN

Projects allocated quantities directly from the Athabasca River.

River Basin Component	
Athabasca #1	4 - industrial projects with 97 585.8 x $10^3 m^3$
Athabasca #2	3 - municipal projects with 866.8 x $10^3 m^3$
Athabasca #3	4 - industrial projects with 190 748.4 x $10^3 m^3$
	3 - municipal projects with 8 754.3 x $10^3 m^3$
TOTAL	14 - active projects allocated to withdraw a total of 297 955.3 x $10^3 m^3$. These account for 76 percent of all allocations in the Athabasca River Basin.

Ranking of River Basin Components according to (a) total number of projects, (b) total allocations (from greatest to least), from Table 3. The ranking reflects levels of activities, density of population and industrial developments within the areas.

(a) Total Number of Projects	(b) Total Allocations
Pembina	Athabasca 3
McLeod	Athabasca 1
Lesser Slave	Pembina
La Biche	Lesser Slave
Athabasca 1	McLeod
Athabasca 2	Athabasca 2
Athabasca 3	La Biche
Clearwater	Clearwater
Berland	Berland

for centres* in the basin are presented in Table 5.

The 1980 water use characteristics, populations, water supply sources, allocations of communities in the basin are presented in Table 6. Since there is no information available on water consumption, and since this may be expected to range between 10 to 20 percent or less of withdrawals**, a consumption figure of 20 percent of gross withdrawals is used. For 1980, the municipal withdrawals were estimated to be 11 729.6 x 10^3m^3 or 59 percent of their total allocation; total municipal consumption amounted to 2 345.5 x 10^3m^3.

In addition to the incorporated centres, there are many small unincorporated settlements scattered throughout the basin. These communities generally rely on local surface or groundwater sources. Because their water use would be relatively insignificant in the basin context, they are included in the rural domestic use category.

Most communities in the basin are fortunate in having either surface or groundwater sources readily available. There are no apparent municipal water problems. Results from an Alberta Environment, Groundwater Branch report (22) indicate that groundwater sources for native communities and small settlements vary considerably in quantity and quality, but generally are adequate. When the need arises to examine any one community's requirements, a water supply study is usually

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* Communities selected were ones with available historical water use data from files and reports in Water Rights Branch, Municipal Engineering Branch, Planning Division, Alberta Environment and community ledgers.

** Based on information provided by Municipal Engineering Branch, Alberta Environment. The Prairie Provinces Water Board Water Demand Study, Municipal and Industrial Water Uses - Alberta, 1982 suggests the general utilization of a 20% figure in the absence of recorded data.

undertaken to determine and plan for specific requirements.

Forecasted

Future municipal water use is very dependent upon the population growth that may occur, which in turn is dependent upon and closely linked to resource developments. The municipal population increases that may result from various potential resource developments are unique to each case and cannot be forecasted on the basis of past trends. Most of the anticipated economic growth and industrial activity is expected to occur in the oil sands area north of Fort McMurray and in the Foothills region near Hinton where coal mining, oil and gas exploration and production activities are expanding.

An indication of potential future water use for several communities was obtained by reviewing various files and reports, summarized in Table 7, that included some information of future requirements. To present a more complete scenario, projections of municipal water use based on forecasts of populations and on per capita water use have been made.

Results of the Prairie Provinces Water Board, Water Demand Study* indicate that residential and municipal water uses are highly correlated with population growth. Although the nature of municipal water use components are somewhat different in the Athabasca Basin than in the Alberta portion of the Saskatchewan-Nelson Basin, such a relationship also appears to exist. To model the relationship between water use and urban population growth, regression analysis has been used on the aggregate

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* Prairie Provinces Water Board Water Demand Study, Municipal and Industrial Water Uses in the Saskatchewan-Nelson Basin: Alberta, by Planning Division, Alberta Environment, March 1982.

TABLE 5

MUNICIPAL WATER USE TRENDS - ATHABASCA RIVER BASIN
(Gross Withdrawals)

COMMUNITY		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Athabasca (S)	P	1 765	1 831	1 831	1 831	1 756	1 759	1 759	1 838	1 878	1 846
	T	155 020	156 840	145 470	79 100	231 390	259 120	125 920	259 580	390 050	390 050
	Lpcpd	240	240	220	120	360	400	200	390	570	580
Barrhead (S)	P	2 803	2 718	2 803	2 860	3 016	2 944	2 944	3 332	3 428	3 519
	T	254 120	299 580	340 500	407 780	405 050	357 320	384 140	416 410	431 420	416 600
	Lpcpd	250	300	330	390	370	330	360	340	350	320
Edson (Gw)	P	3 818	4 060	4 095	4 079	4 111	4 038	4 448	5 015	5 403	5 671
	T	371 860	400 960	405 500	458 240	510 180*	486 380*	470 820*	640 670*	765 940	795 038
	Lpcpd	270	270	270	310	340*	330*	290*	350*	290	380
Fort McMurray (S)	P	6 847	7 147	8 148	9 542	13 393	15 424	20 373	24 580	25 802	27 784
	T	694 630	863 290	824 640	1 271 970	1 527 460	2 583 040	4 163 230	4 028 210	4 524 180	4 584 190
	Lpcpd	280	330	280	370	310	460	560	450	480	450
High Prairie (Gw)	P	2 354	2 650	2 698	2 698	2 698	2 281	2 281	2 281	2 281	2 281
	T	274 580	276 850	259 580	297 310	333 220	321 670	310 550	283 070*	291 400*	266 420*
	Lpcpd	320	290	260	300	340	390	370	340*	350*	320*
Hinton (S)	P	4 911	4 690	5 326	5 626	6 266	6 731	7 067	7 319	7 412	8 018
	T	1 358 800	1 691 650	1 381 080	1 680 200	1 810 670	1 964 780	1 746 120	1 650 200	1 791 120	1 975 240
	Lpcpd	760	990	710	820	790	800	680	620	660	670
Lac La Biche (S)	P	1 791	1 743	1 743	1 900	1 964	1 954	1 954	1 954	1 991	2 035
	T	156 890*	152 690*	139 960*	83 220*	258 070*	258 210	329 590	435 500	467 780	405 960
	Lpcpd	240*	240*	220*	120*	360*	360	460	610	640	550
Mayerthorpe (Gw)	P	1 036	1 042	1 036	1 036	1 031	1 018	1 180	1 282	1 360	1 502
	T	96 380	93 190	112 290	128 570*	127 950*	122 620*	124 900*	163 780*	143 960*	208 330*
	Lpcpd	250	250	250	340*	340*	330*	290*	350*	290*	380*
Plamondon (S)	P	189	190	190	190	215	228	228	228	236	236
	T	9 550	16 820	23 190	29 090	30 460	27 460*	29 960*	28 300*	30 150*	27 570*
	Lpcpd	140	240	330	420	390	330*	360*	340*	350*	320*
Slave Lake (S)	P	2 052	2 166	2 836	3 240	3 449	3 561	3 561	3 561	3 821	4 328
	T	187 250*	237 180*	341 600*	473 690	641 440	569 160	569 160	548 700	577 800	623 710
	Lpcpd	250*	300*	330*	400	510	440	440	420	410	400
Swan Hills (S,Gw)	P	1 376	1 804	2 038	2 169	2 197	2 012	2 206	2 351	2 553	2 553
	T	113 000*	148 500*	167 370*	178 200	175 930	165 240*	181 170*	193 080*	209 670*	209 670*
	Lpcpd	225*	225*	225*	230	220	225*	225*	225*	225*	225*
Westlock (S)	P	3 246	3 422	3 524	3 603	3 669	3 721	3 824	3 824	3 824	3 824
	T	406 410	335 040	409 140	460 510	477 790	534 610	397 780	488 520*	404 770*	589 620
	Lpcpd	340	270	320	350	360	390	290	350*	290*	420
Whitecourt (S)	P	3 202	3 155	3 230	3 306	3 549	3 878	4 056	4 400	4 758	5 153
	T	315 490	355 500	364 500	404 140	443 690	460 060	427 320	560 070	510 970	721 600
	Lpcpd	270	290	290	310	330	330	290	320	290	350
Gross Totals	P	35 390	36 618	39 498	42 080	47 314	49 549	55 881	61 965	64 745	68 750
	T	4 393 980	5 027 740	4 914 910	5 952 020	6 973 300	8 109 670	9 260 660	9 696 090	10539 210	11213 998
	Lpcpd	340	376	340	387	403	448	454	428	446	446

NOTES: All values have been rounded off.
S - surface water source; P - population
Gw - groundwater source; T - total annual withdrawal in cubic metres
Lpcpd - estimated litres per capita per day use

SOURCES: 1) Fluoridation record sheets and municipal records
2) Calculations for Lpcpd based on Statistics Canada census population figures, and additional figures from Municipal Inspection and Advisory Services Branch, Alberta Municipal Affairs.

* Missing data constructed by imposing closest historical level, and trend of withdrawals from similar communities upon the missing years. The trend in the following communities were found to be closely similar: Slave Lake, Plamondon, and High Prairie with Barrhead; Mayerthorpe, Westlock, and Edson with Whitecourt; Lac La Biche with Athabasca.
Swan Hills' average of 225 Lpcpd calculated from the two years of recorded withdrawals.

TABLE 6

ATHABASCA RIVER BASIN - MUNICIPAL WATER USE 1980

RIVER BASIN COMPONENT	COMMUNITY	POPULATION	WATER SOURCE	WATER USE ($10^3 m^3$) ALLOCATION	WITHDRAWAL	CONSUMPTION
Athabasca 1	Hinton	8 018	S	through NWPP works	1 975.2	395.0
	Whitecourt	5 153	S	4 808.7	721.6	144.2
	Swan Hills	2 553	S/G	802.7	209.7	41.9
	Fort Assiniboine	194	P/G	---	31.6*	6.3
	Total	15 908	-	5 611.4	2 938.1	587.4
Athabasca 2	Athabasca	1 846	S	807.6	390.0	78.0
Athabasca 3	Fort McMurray	27 784	S	7 521.3	4 584.2	916.8
Berland	---	---	---	---	---	---
McLeod	Edson	5 671	G	1 484.5	795.0	159.0
Pembina	Mayerthorpe	1 502	G	226.9	208.3	41.7
	Sangudo	422	G	74.0	68.7*	13.7
	Westlock	3 824	S	845.8	589.6	117.9
	Barrhead	3 519	S	733.6	416.6	83.3
	Evansburg	801	G/S	212.1	115.5	23.1
	Entwistle	499	G	67.8	81.2*	16.2
	Wildwood	445	G	113.4	72.4*	14.4
	Total	11 012	-	2 273.6	1 552.3	310.3
Lesser Slave	High Prairie	2 281	S/G	---	266.4	53.3
	Kinuso	305	S	92.5	40.3	8.1
	Slave Lake	4 328	S	246.6	623.7	124.7
	Total	6 914	-	339.1	930.4	186.1
La Biche	Boyle	651	S	111.0	106.0*	21.2
	Plamondon	236	S	104.8	27.6	5.5
	Lac La Biche	2 035	S	1 615.2	406.0	81.2
	Total	2 922	-	1 831.0	539.6	107.9
Clearwater	---	---	-	---	---	---
TOTALS	---	72 057	-	19 868.5	11 729.6	2 345.5

NOTES:

1. River Basin Components as indicated in text.
2. 1980 population figures from Municipal Inspection and Advisory Services Branch, Municipal Affairs.
3. S - surface water source
   G - groundwater source
   P - private system usually groundwater wells.
4. Allocation figures obtained from computer printout of active licenses by Water Rights Branch as of September 1981.
5. Withdrawal figures obtained from community waterworks files, Fluoride Record Sheet Summaries for 1980, by Municipal Engineering Branch, Alberta Environment, or as calculated (see notes with Table 5).
6. There is not information on municipal water consumption. A consumptive figure of 20% was assumed.

* Denotes smaller communities not covered in Table 5 and for which records were not readily available. A figure of 446 litres or about 98.1 gallons per capita per day (the average of communities in Table 5) was applied to estimate withdrawals.

TABLE 7

ATHABASCA RIVER BASIN - SELECTED COMMUNITIES
FUTURE GROWTH POTENTIALS - WATER USE INDICATORS

COMMUNITY AND RIVER BASIN COMPONENT	COMMENTS
Whitecourt (Athabasca 1)	(RS) Estimated % population rate increase of 8.7% and % water withdrawal rate increase of 10.6% annually. By 1986 population of 8,000 and water use of about 472,800 m^3 by 1996 will have risen to 11,300 people with water use of $1.1 \times 10^6 m^3$.
	(FS) Its anticipated water use by year 2016 will be $4.8 \times 10^6 m^3$. In the next 30 years population is expected to double several times, plus some industries are expected.
Blue Ridge (Athabasca 1)	(RS) Located near Whitecourt, Simpson Timber operations commitment. Good potential for forestry related industrial developments.
Hinton (Athabasca 1)	(RS) Much development potential and growth due to pulp mill expansion, coal mining operations, oil and gas exploration activities. Has high per capita water use rate, see Table 5. Anticipated increases in population are as follows: 1986 10,490-15,550 1991 11,640-18,240
Swan Hills (Athabasca 1)	(FS) Future growth anticipated at 7%/year but very dependent upon new resource development. By the year 2000 expected population of 7,500 and water use of $1 \times 10^6 m^3$.
Athabasca (Athabasca 2)	(FS) Community functions as agricultural service centre. Its population increased about100 people over 10 years. Trend is indicative of continued slow growth unless resource related industry were to locate near the town.
Fort McMurray (Athabasca 3)	(RS) The community has grown rapidly in the latter part of the 1970's. Because of its location near the oil sands it is likely to continue experiencing growth. Forecasted water requirements are: Year / Water Use (m^3): 1984 $4.0 \times 10^6 m^3$; 1989 $4.7 \times 10^6 m^3$; 1994 $5.4 \times 10^6 m^3$; 2000 $6.3 \times 10^6 m^3$
Fort McKay (Athabasca 3)	(RS) Although this community's requirements are much smaller compared to Fort McMurray, they would still have an impact on the local resources. The forecasted growth for the community is as follows: Year / Population / Water Use (m^3/year): 1986 442 66,830; 1991 564 90,010; 1996 720 120,470; 2000 876 152,750
New Town (Athabasca 3)	(RS) Potential exists to develop a new town, like Fort McMurray but at some distance north of it that would be a service centre to potential oil sands plants and related operations. The forecasted requirements for the new town are as follows: Year / Water Use (m^3/year): 1986 $3.3 \times 10^6 m^3$; 1991 $5.0 \times 10^6 m^3$; 1996 $11.5 \times 10^6 m^3$; 2000 $14.8 \times 10^6 m^3$
Anzac (Clearwater)	(RS) This is a small community, but its close location to a potential in-situ oil sands operation provides some possibilities for growth. Its projected growth is as follows: Year / Population / Water Use (m^3/year): 1986 277 41,820; 1991 354 56,370; 1996 454 75,920; 2000 552 96,380

TABLE 7 Continued...

COMMUNITY AND RIVER BASIN COMPONENT	COMMENTS

Janvier (Clearwater)

(RS) Similar conditions apply to this community as to Anzac. Its projected growth is:

Year	Population	Water Use (m^3/year)
1986	580	87,740
1991	740	117,740
1996	945	158,200
2000	1,149	200,020

Edson (McLeod)

(RS) Records for town indicate increases in total and per capita water use. Overall trend is for continued increases. Growth stimulus could result from development coal resources. Its growth is consequent upon probable location of coal mines. Growth estimates are as follows:

Year	Population	Water Use (m^3/year)
1986	4,880-5,870	681,870-820,220
1991	5,320-6,400	808,880-972,970
1996	5,800-6,980	920,290-1,146,470

Barrhead (Pembina)

(RS) This community is an agricultural service centre. It is anticipated that it will continue to grow at a steady rate. The town's water requirements are expected to rise due to higher industrial and commercial use, as well as greater per capita use due to wider utilization of convenience items (eg. dishwashers, automatic washers). The forecasted growth is as follows: (based on 9.0 Lpcpd/year increase)

Year	Population	Water Use (m^3/year)
1986	3,675	530,520
1991	3,960	584,800
1996	4,235	640,980
2000	4,480	908,720

Westlock (Pembina)

(RS) This community is also an agricultural service centre. Continued growth is anticipated. Its forecasted growth is:

Year	Population	Water Use (m^3/year)
1986	5,300	870,530
1991	6,400	1,051,200
1996	7,600	1,248,200
2000	8,700	1,428,980

Slave Lake (Lesser Slave)

(RS) This community has experienced and will continue to experience a slow but steady trend in growth that is related to forest products and oil field service industries.

High Prairie (Lesser Slave)

(RS) Forecasted growth for this town is as follows:

Year	Population	Water Use (m^3/year)
1986	4,600	528,890
1991	5,100	586,890
1996	5,600	643,860
2000	6,100	701,350

Lac La Biche (La Biche)

(FS) This community has experienced steady growth over the past. On the basis of continued growth the following forecasts are derived:

Year	Population	Water Use (m^3/year)
1986	3,500	574,880
1991	5,400	886,950
1996	6,650	1,092,260
2000	8,160	1,340,280

It is anticipated that by the year 2001 water use may have risen to 1,423,800 m^3.

Plamondon (La Biche)

(RS) Forecasts for this village have been made.

Year	Population	Water Use (m^3/year)
1986	600	69,540
2000	1,500	173,850

NOTE: RS - report source; FS - file source } Water Rights, Alberta Environment forecasted urban population levels shown in Table 1 and water use trends shown in Table 5. The result was a relationship of the form:

$$Gw = -803\ 063\ 444.4 + 407\ 776.2Y + 111.4P$$

where Gw = gross withdrawals in m^3

Y = year

P = population =)1.23966 x 10^{-3} $Y^{4.08}$)

and $r^2 = 0.984$.

This relationship provides reasonable estimates of withdrawals. Forecasted withdrawals and population figures, summarized in Table 8, were distributed among the river basin components based upon 1981 population distribution.

Summary

Municipal water use in the basin is summarized in Table 8. Municipal water use, given the continuance of the present trend, is expected to increase from a total of 12 397.3 x 10^3m^3 in 1981 to 30 910.8 x 10^3m^3 by 2001. The Athabasca 3 component containing the City of Fort McMurray was determined to have the greatest municipal water use in 1981. Forecasts indicate that this component will also have the greatest municipal water use in the year 2001, followed by the Athabasca 1, Pembina, Lesser Slave and McLeod sub-basin components. The greatest percentage increases are forecasted to occur in both the McLeod and La Biche components (164 percent each) followed by the Athabasca 1 (155 percent), Athabasca 3 (148 percent), Pembina (145 percent), Lesser Slave (137 percent), and Athabasca 2 (121 percent) components.

TABLE 8

MUNICIPAL WATER USE FORECASTS - ATHABASCA RIVER BASIN

						WATER USE ($10^3 m^3$)							
		POPULATION				WITHDRAWAL				CONSUMPTION			
RIVER BASIN COMPONENT	% DISTRIB	1981	1986	1991	2001	1981	1986	1991	2001	1981	1986	1991	2001
Athabasca 1	22	16 271	20 064	25 322	38 896	2 666.6	3 398.0	4 427.2	6 800.4	533.3	679.6	885.4	1 360.1
Athabasca 2	2	1 707	1 824	2 302	3 536	279.8	308.9	402.5	618.2	56.0	61.8	80.5	123.6
Athabasca 3	40	30 368	36 480	46 040	70 720	4 976.9	6 178.3	8 049.4	12 364.3	995.4	1 235.7	1 609.9	2 472.9
Berland	--	--	--	--	--	--	--	--	--	--	--	--	--
McLeod	8	5 726	7 296	9 208	14 144	938.4	1 235.7	1 609.9	2 472.9	187.7	247.1	322.0	494.6
Pembina	15	11 556	13 680	17 265	26 520	1 893.9	2 316.8	3 018.5	4 636.6	378.8	463.4	603.7	927.3
Lesser Slave	9	7 161	8 208	10 359	15 912	1 173.6	1 389.8	1 811.1	2 782.0	234.7	278.0	362.2	556.4
La Biche	4	2 856	3 648	4 604	7 072	468.1	617.8	804.9	1 236.4	93.6	123.6	161.0	247.3
Clearwater	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	100	75 645	91 200	115 100	176 800	12 397.3	15 445.3	20 123.5	30 910.8	2 479.5	3 089.2	4 024.7	6 182.2

NOTES:

1. Total basin population figures taken from Table 1.
2. Forecasted population figures were determined from the relationship: $P = 1.23966 \times 10^{-3}\ Y^{4.08}$
   where P = population
   Y = year
   $r^2 = 0.987$

   Resulting totals were distributed among the river basin components by percentages indicated in the table based upon 1981 population distributions. It is assumed that the basin components will have similar population distributions throughout the forecast period.
3. Gross water withdrawals were determined from the relationship: $Gw = -803\ 063\ 444.4 + 407\ 776.2\ Y + 111.4\ P$
   where Gw = gross withdrawals in m^3
   Y = year
   P = population as calculated in (2) above
   and $r^2 = 0.984$

   Per capita withdrawals were calculated to increase from 446 Lpcpd in 1980 at a rate of 3 Lpcpd per year to 479 Lpcpd by 1990 from which point onwards it remains at that level.
4. Consumption figures are based on a 20% consumptive use estimate of gross withdrawals.

AGRICULTURAL WATER USE

General Characteristics

The Athabasca Basin lies on the fringe area of lands suitable for agricultural activities. Although the land use pattern is dominated by forests, there are regions, two of which are the lower Pembina River and the Tawatinaw River - Pine Creek areas, where agricultural activities are dominant. As the agricultural capacities of many areas are nil to low, further extensions of agricultural activities are anticipated to be minimal. Furthermore, the overall agricultural water uses are expected to be minimal in comparison to other uses, particularly industry-related.

The mainstay of the agricultural sector is mixed farming accompanied by livestock rearing and feed crop growing. Grazing of animals also occurs within the forest producing areas. Agricultural land use in 1971 constituted the following (58):

14 470 000	hectares (ha) total area
1 260 445	ha of farmland, amounting to 8.7 percent of the total basin area
502 708	ha of cropland
165	ha of irrigated land

Precipitation in, and surface and groundwater resources throughout the basin have generally been reliable for agricultural purposes. These sources are also considered to be adequate to support future agricultural activities.

In the agricultural sector, water is used for irrigation, stock-watering and rural residential purposes. Accurate data concerning water use for these purposes in the basin are not available. To indicate some levels of agricultural water use, each of the aforementioned categories was examined separately. The summary of active licensed projects in Table 3 indicates that there are 157 agricultural type projects having a total allocation of 2 834.6 x 10^3m^3 annually (32 feedlots with 189.9 x 10^3m^3, 97 domestic with 594.3 x 10^3m^3 and 28 irrigation with 2 050.4 x 10^3m^3). The allocated quantities are the maximum permissible withdrawals, and are not representative of actual withdrawals. Nevertheless, the allocations are useful in placing agricultural water use in perspective within the basin.

Rural Domestic and Reservations Water Use

Historical and Current

The points at which water is withdrawn and used for rural domestic purposes are widely dispersed throughout the basin. Rural domestic water requirements including water for livestock and rural household purposes have generally been met by both local surface and groundwater sources. To what extent these resources have been and are being used is not known. There are no statistics available which describe residential water use on the farm or on reservations.

An indication of water use for rural residential purposes was obtained by combining rural and reservation population and per capita water use figures, assuming a high correlation between water use and population, as for the municipal sector. An average per capita use rate of 190 L* was utilized in deriving the water use estimates in

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* A figure of 190 Lpcpd is suggested for rural domestic withdrawals and consumption by the Prairie Provinces Water Board Water Demand Study, Agricultural Water Uses in the Saskatchewan-Nelson Basin: Alberta, 1982.

TABLE 9

RURAL DOMESTIC WATER USE FORECASTS -
FARMS AND RESERVATIONS
ATHABASCA RIVER BASIN

YEAR	POPULATION	WATER USE (10^3m^3) WITHDRAWALS	CONSUMPTION
1951	51 381	3 563.3	3 563.3
1956	52 949	3 672.0	3 672.0
1961	49 276	3 417.3	3 417.3
1966	48 288	3 348.8	3 348.8
1971	44 905	3 114.2	3 114.2
1976	42 878	2 973.6	2 973.6
1981	41 350	2 867.6	2 867.6
1986	39 910	2 767.8	2 767.8
1991	38 480	2 668.6	2 668.6
1996	37 080	2 571.5	2 571.5
2001	35 680	2 474.4	2 474.4

NOTES:

1. 1951 to 1976 population figures from Table 1.
2. 1981 through to 2001 population figures estimated on basis of historical trend, P = 569 406.79 - 226.54 Y for rural farm populations, and 1951-1976 trend for Indian reservations populations.
3. Water use estimates (withdrawals and consumption) based on constant rate of 190 Lpcpd assuming that rural domestic water use does not change appreciably over time. Further, based on information in Prairie Provinces Water Board Water Demand Study, Agricultural Water Uses in the Saskatchewan-Nelson Basin: Alberta, by Planning Division, Alberta Environment, May 1982. Consumption is assumed equal to withdrawals as return flows from rural uses are generally not to the source of supply.

Table 9. According to population trends in Table 1, rural farm residents have declined steadily since 1956, an average of about 350 people annually from 49 320 in 1956 to 40 900 in 1981. According to the 1951 to 1976 trend for Indian reservations, this population has also decreased, but a stabilization of this population below 400 in the near future is suggested. Total rural domestic water use for 1981 was estimated at 7 856.5 x 10^3 L per day or 2 867.6 x $10^3 m^3$ for the year.

Forecasted

The 1981 rural population including that for farms and reservations, as shown in Table 9, has declined about 22 percent since 1956, and given the continuing declining trend further decreases will occur. From a statistical analysis of population projections, it is inferred that rural population and rural domestic water use are expected to continue to decrease to 2 474.4 x $10^3 m^3$ by 2001. Table 9 presents gross estimates for the whole basin, whereas Table 10 summarizes anticipated future rural domestic water uses for the sub-basin components. The projections are based on the assumption that rural domestic water use will not change appreciably in the future, that is, it will remain at a level of 190 Lpcpd.

Livestock Water Use

Historical and Current

Stockwatering needs depend on the size and composition of the livestock populations. Although in recent years the numbers of total livestock in the province have increased, over the past 20 years there have been substantial fluctuations in the size of the livestock population. When short term cycles and fluctuations are discounted,

TABLE 10

RURAL DOMESTIC WATER USE FORECASTS
FARMS AND RESERVATIONS
BY RIVER BASIN COMPONENTS
ATHABASCA RIVER BASIN

RIVER BASIN COMPONENT	ESTIMATED POPULATION				WATER USE ($10^3 m^3$) ESTIMATED WITHDRAWALS				WATER USE ($10^3 m^3$) ESTIMATED CONSUMPTION			
	1981	1986	1991	2001	1981	1986	1991	2001	1981	1986	1991	2001
Athabasca 1	2 895	2 794	2 694	2 500	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
Athabasca 2	2 895	2 794	2 694	2 500	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
Athabasca 3	---	---	---	---	---	---	---	---	---	---	---	---
Berland	205	200	192	170	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
McLeod	2 895	2 794	2 694	2 500	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
Pembina	25 225	24 344	23 470	21 770	1 749.4	1 688.2	1 627.6	1 509.6	1 749.4	1 688.2	1 627.6	1 509.6
Lesser Slave	2 895	2 794	2 694	2 500	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
La Biche	4 135	3 990	3 850	3 570	286.8	276.6	267.0	247.6	286.8	276.6	267.0	247.6
Clearwater	205	200	192	170	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
BASIN TOTAL	41 350	39 910	38 480	35 680	2 867.6	2 767.8	2 668.6	2 474.4	2 867.6	2 767.8	2 668.6	2 474.4

NOTES:

1. Total population estimates based on figures in Table 9. Each sub-basin component's rural population figures calculated from percentage distribution of total number of agricultural, domestic and irrigation projects in each component from Table 3.
2. Withdrawal and consumptive water use estimates calculated as in Table 9.

however, the general trend has been one of gradual increase in livestock populations and water use.

It appears that livestock water requirements have been adequately met by the water resources in the basin. Livestock water use is not licensed separately, and is included in the domestic category, unless it is specifically required for feedlot purposes. There are 32 projects that are allocated 189.9 x $10^3 m^3$ annually from groundwater sources for feedlots.

In order to indicate possible levels of water use for livestock purposes, it was assessed on estimated animal numbers by category from Statistics Canada data for 1971 and 1976, and average daily water use coefficients (see Table 12) for various animal types. In examining the livestock data for 1971 and 1976 (see Table 11), it may be noted that cattle increased 56 percent, pigs decreased 52 percent, sheep declined 10 percent, poultry increased 3 percent, and other livestock decreased 24 percent over that period.

Forecasted

The estimation of future livestock populations, size and composition, their distribution and related water uses is difficult due to primarily unpredictable market conditions. Future livestock numbers and water use estimates were obtained by projecting the trends in animal categories and applying animal unit water use figures as in the foregoing historical section.

Results from the Prairie Provinces Water Board Water Demand Study (64) indicate that total livestock increases in the neighbouring North Saskatchewan River Basin have, as a whole, increased at a

3 percent annual rate linearly over a 27 year period. Long term cattle populations in the North Saskatchewan River Basin have increased an average of 4 percent annually, and due to the lack of similar historic data for the Athabasca River Basin, this value is used to forecast cattle populations in the basin. Similar trends for the remaining categories are imposed; pigs, poultry, and other livestock types are assumed to remain constant, while sheep are assumed to decline 1 percent per year over the forecast period. The livestock projections are summarized in Table 11. Table 12 provides forecasts for livestock and water use for the sub-basin components. The numbers in Table 12 were calculated by using a percentage distribution based on the number of agricultural and domestic projects listed in Table 3. In deriving the water use forecasts in Table 12, it was assumed that the uses will generally be the same on a per unit basis in the future, and also that the same factors currently affecting this use will continue to influence the quantities of water use for this purpose in the future. Provided the trend in livestock populations will continue, livestock water uses can be expected to amount to 21 031.2 x $10^3 m^3$ by 2001.

Irrigation Water Use

Historical and Current

Irrigation water use is characterized by a number of point withdrawals scattered throughout the basin, as shown in Figure 3. Irrigation for crops is that water required over and above precipitation. The peak use occurs during the summer months when crops have the greatest water requirements and the evaporative losses are also

TABLE 11

ESTIMATED TOTAL LIVESTOCK NUMBERS
ATHABASCA RIVER BASIN

	TYPE OF LIVESTOCK					
YEAR	CATTLE	PIGS	SHEEP	POULTRY	OTHER	TOTAL
1971	232 513	188 977	19 074	486 265	98 928	1 025 757
1976	361 691	91 485	17 145	492 625	74 779	1 037 725
1981	434 000	91 500	16 300	492 600	75 000	1 109 400
1986	506 300	91 500	15 400	492 600	75 000	1 180 800
1991	578 600	91 500	14 500	492 600	75 000	1 252 200
2001	723 300	91 500	12 800	492 600	75 000	1 395 200

NOTES:

1. 1971 and 1976 estimates from Statistics Canada Census data.
2. 1981 through to 2001 estimates based on trends from the North Saskatchewan Basin historic data:
   - cattle - increase of 4% annually
   - pigs, poultry and other - figures rounded and kept constant
   - sheep - decrease of 1% annually.

TABLE 12

LIVESTOCK AND WATER USE FORECASTS
BY RIVER BASIN COMPONENTS
ATHABASCA RIVER BASIN

RIVER BASIN COMPONENT	YEAR	ESTIMATED NUMBER OF LIVESTOCK						ESTIMATED WATER USE ($10^3 m^3$)					
		CATTLE	PIGS	SHEEP	POULTRY	OTHER	TOTAL	CATTLE	PIGS	SHEEP	POULTRY	OTHER	TOTAL
McLeod	1971	18 600	15 120	1 530	38 900	7 920	82 070	530.1	33.3	2.0	3.9	15.8	585.1
	1981	34 720	7 320	1 300	39 400	6 000	88 740	989.5	16.1	1.7	3.9	12.0	1 023.2
	1986	40 500	7 320	1 230	39 400	6 000	94 450	1 154.3	16.1	1.6	3.9	12.0	1 187.9
	1991	46 200	7 320	1 160	39 400	6 000	100 170	1 319.3	16.1	1.5	3.9	12.0	1 352.8
	2001	57 860	7 320	1 020	39 400	6 000	111 600	1 649.0	16.1	1.3	3.9	12.0	1 682.3
Lesser Slave	1971	20 930	17 000	1 720	43 760	8 900	92 310	596.5	37.4	2.2	4.4	17.8	658.3
	1981	39 060	8 240	1 470	44 330	6 750	99 850	1 113.2	18.1	1.9	4.4	13.5	1 151.1
	1986	45 560	8 240	1 390	44 330	6 750	106 270	1 298.5	18.1	1.8	4.4	13.5	1 336.3
	1991	52 070	8 240	1 300	44 330	6 750	112 690	1 484.0	18.1	1.7	4.4	13.5	1 521.7
	2001	65 100	8 240	1 150	44 330	6 750	125 570	1 855.4	18.1	1.5	4.4	13.5	1 892.9
La Biche	1971	20 930	17 000	1 720	43 760	8 900	92 310	596.5	37.4	2.2	4.4	17.8	685.3
	1981	39 060	8 240	1 470	44 330	6 750	99 850	1 113.2	18.1	1.9	4.4	13.5	1 151.1
	1986	45 560	8 240	1 390	44 330	6 750	106 270	1 298.5	18.1	1.8	4.4	13.5	1 336.3
	1991	52 070	8 240	1 300	44 330	6 750	112 690	1 484.0	18.1	1.7	4.4	13.5	1 521.7
	2001	65 100	8 240	1 150	44 330	6 750	125 570	1 855.4	18.1	1.5	4.4	13.5	1 892.9
Pembina	1971	139 500	113 400	11 400	291 760	59 350	615 450	3 975.8	249.5	14.8	29.2	118.7	4 388.0
	1981	260 400	54 900	9 780	295 560	45 000	665 640	7 421.4	120.8	12.7	29.6	90.0	7 674.5
	1986	303 800	54 900	9 240	295 560	45 000	708 500	8 658.3	120.8	12.0	29.6	90.0	8 910.7
	1991	347 160	54 900	8 700	295 560	45 000	751 320	9 894.1	120.8	11.3	29.6	90.0	10 145.8
	2001	433 980	54 900	7 680	295 560	45 000	837 120	12 368.4	120.8	10.0	29.6	90.0	12 618.8
Athabasca 1	1971	13 950	11 340	1 140	29 180	5 940	61 550	397.6	24.9	1.5	2.9	11.9	438.8
	1981	26 040	5 480	980	29 580	4 500	66 580	742.1	12.1	1.3	3.0	9.0	767.5
	1986	30 380	5 480	920	29 580	4 500	70 860	865.8	12.1	1.2	3.0	9.0	891.1
	1991	34 720	5 480	880	29 580	4 500	75 160	989.5	12.1	1.1	3.0	9.0	1 014.7
	2001	43 400	5 480	780	29 580	4 500	83 740	1 236.9	12.1	1.0	3.0	9.0	1 262.0
Athabasca 2	1971	18 600	15 120	1 530	38 900	7 920	82 070	530.1	33.3	2.0	3.9	15.8	585.1
	1981	34 720	7 320	1 300	39 400	6 000	88 740	989.5	16.1	1.7	3.9	12.9	1 023.2
	1986	40 500	7 320	1 230	39 400	6 000	94 450	1 154.3	16.1	1.6	3.9	12.9	1 187.9
	1991	46 290	7 320	1 160	39 400	6 000	100 170	1 319.3	16.1	1.5	3.9	12.9	1 352.8
	2001	57 860	7 320	1 020	39 400	6 000	111 600	1 649.0	16.1	1.3	3.9	12.9	1 682.3
BASIN TOTALS	1971	232 510	188 980	19 080	486 260	98 930	1 025 760	6 626.6	415.8	24.7	48.7	197.8	7 313.6
	1981	434 000	91 500	16 300	492 600	75 000	1 109 400	12 368.9	201.3	21.2	49.2	150.0	12 790.6
	1986	506 300	91 500	15 400	492 600	75 000	1 180 800	14 429.7	201.3	20.0	49.2	150.0	14 850.2
	1991	578 600	91 500	14 500	492 600	75 000	1 252 200	16 490.2	201.3	18.8	49.2	150.0	16 909.5
	2001	723 300	91 500	12 800	492 600	75 000	1 395 200	20 614.1	201.3	16.6	49.2	150.0	21 031.2

NOTES:

1. Livestock numbers were calculated from Table 11. Sub-basin component livestock numbers were calculated by applying a percentage figure to each livestock category. The percentages applied to the sub-basins were obtained from examining the percentage distribution of livestock type projects (in agriculture and domestic) in Table 3. The corresponding percentage figures are: McLeod and Athabasca 2, 8% each; Lesser Slave and La Biche, 9% each; Athabasca 1, 6%; and Pembina, 60%. Nil for Berland, Clearwater and Athabasca 3.

2. Livestock water use estimates were based on the following figures derived from PPWB (64) and other sources:

   Cattle 78L/animal/day or 28.5 m^3/animal/year
   Pigs 6L/animal/day or 2.2 m^3/animal/year
   Sheep 3.5L/animal/day or 1.3 m^3/animal/year
   Poultry 0.4L/animal/day or 0.1 m^3/animal/year
   Other livestock category consists of a mixture of animals and thus an assumed average of 5L/animal unit/day or 2.0 m^3/unit/year is applied.

   It is assumed that whatever is withdrawn for livestock purposes will also be consumed.

3. Totals may vary slightly from those in Table 11 due to percentage distribution and rounding off.

high. The moisture requirements of crops in the basin are generally met by annual amounts of precipitation, but a limited amount of irrigation is practiced.

There are no significant irrigation projects that divert water from the Athabasca or its major tributary river systems. All irrigation activity is private in nature and includes operations for fodder crop production (feed supplies and grazing areas), sod farms, golf courses, and market gardening. According to Table 3, there are currently 28 irrigation projects in the basin with a total water allocation of 2 050.4 x $10^3 m^3$ or an average of about 73 230 m^3 per project. The majority of the licensed projects, 19 or 68 percent of them, are located in the Pembina River sub-basin.

Forecasted

The future use of water for irrigation will be dependent upon many factors. According to Water Rights information, the number of irrigation projects has increased slowly but steadily, an average of 1 project annually since 1965. This trend is expected to continue into the future.

For purposes of estimating irrigation requirements, it was assumed that the number of irrigation projects will continue to increase at the past rate, that is 1 project with an average allocation of 73 230 m^3 annually. Furthermore, it is assumed that whatever is withdrawn for irrigation purposes will also be consumed. The resulting estimated irrigation water uses in the basin are summarized in Table 13.

TABLE 13

IRRIGATION WATER USE FORECASTS
ATHABASCA RIVER BASIN

YEAR	NUMBER OF PROJECTS	ALLOCATED WATER USE (m^3)
1981	28	2 050 440
1986	33	2 416 590
1991	38	2 782 740
2001	48	3 515 040

NOTE: Estimates are based on increase of one irrigation project per year and an estimated average allocation of 73 230 m^3 annually per project.

Summary

Agricultural water uses in the Athabasca Basin are summarized in Table 14. Generally, the table shows that quantities of water required for agricultural activities are relatively modest. Agricultural water uses are expected to increase from a total of 17 708.7 x $10^3 m^3$ in 1981 to 27 021.0 x $10^3 m^3$ by 2001. The livestock category accounts for an average of 75 percent of total agricultural water use over the 1981 to 2001 period. In terms of the livestock component, cattle constantly account for over 90 percent of that water use. The rural domestic category is shown to decrease gradually, accounting for 16 percent or 2 867.6 x $10^3 m^3$ of total agricultural water use in 1981 and 9 percent or 2 474.4 x $10^3 m^3$ by 2001. Irrigation water use is forecast to increase slowly, accounting for 12 percent of 2 050.5 x $10^3 m^3$ of total in 1981 to 13 percent of 3 515.4 x $10^3 m^3$ by 2001. The Pembina River sub-basin had the largest agricultural water uses in 1981. Forecasts

TABLE 14

SUMMARY OF AGRICULTURAL WATER USE - BY RIVER BASIN COMPONENTS
ATHABASCA RIVER BASIN
1981-2001

RIVER BASIN COMPONENT	PURPOSE	WATER USE (10^3m^3) ESTIMATED WITHDRAWALS 1981	1986	1991	2001	ESTIMATED CONSUMPTION 1981	1986	1991	2001
Berland	Domestic	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
	Livestock	---	---	---	---	---	---	---	---
	Irrigation	---	---	---	---	---	---	---	---
	Total	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
McLeod	Domestic	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
	Livestock	1 023.2	1 187.9	1 352.8	1 682.3	1 023.2	1 187.9	1 352.8	1 682.3
	Irrigation	73.2	86.2	99.0	124.6	73.2	86.2	99.0	124.6
	Total	1 297.2	1 467.9	1 638.6	1 980.3	1 297.2	1 467.9	1 638.6	1 980.3
Pembina	Domestic	1 749.4	1 688.2	1 627.6	1 509.6	1 749.4	1 688.2	1 627.6	1 509.6
	Livestock	7 674.5	8 910.7	10 145.8	12 618.8	7 674.5	8 910.7	10 145.8	12 618.8
	Irrigation	1 391.4	1 640.4	1 889.4	2 387.4	1 391.4	1 640.4	1 889.4	2 387.4
	Total	10 815.3	12 239.3	13 662.8	16 515.8	10 815.3	12 239.3	13 662.8	16 515.8
Lesser Slave	Domestic	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
	Livestock	1 151.1	1 336.3	1 521.7	1 892.9	1 151.1	1 336.3	1 521.7	1 892.9
	Irrigation	---	---	---	---	---	---	---	---
	Total	1 351.9	1 530.1	1 708.5	2 006.3	1 351.9	1 530.1	1 708.5	2 006.3
La Biche	Domestic	286.8	276.6	267.0	247.6	286.8	276.6	267.0	247.6
	Livestock	1 151.1	1 336.3	1 521.7	1 892.9	1 151.1	1 336.3	1 521.7	1 892.9
	Irrigation	366.2	432.1	498.0	529.8	366.2	432.1	498.0	529.8
	Total	1 804.1	2 045.0	2 286.7	2 670.3	1 804.1	2 045.0	2 286.7	2 670.3
Clearwater	Domestic	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
	Livestock	---	---	---	---	---	---	---	---
	Irrigation	---	---	---	---	---	---	---	---
	Total	14.1	13.9	13.4	11.8	14.1	13.9	13.4	11.8
Athabasca 1	Domestic	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
	Livestock	767.5	891.1	1 014.7	1 262.0	767.5	891.1	1 014.7	1 262.0
	Irrigation	146.5	172.1	197.7	249.0	146.5	172.1	197.7	249.0
	Total	1 114.8	1 257.0	1 399.2	1 684.4	1 114.8	1 257.0	1 399.2	1 684.4
Athabasca 2	Domestic	200.8	193.8	186.8	173.4	200.8	193.8	186.8	173.4
	Livestock	1 023.2	1 187.9	1 352.8	1 682.3	1 023.2	1 187.9	1 352.8	1 682.3
	Irrigation	73.2	86.2	99.0	124.6	73.2	86.2	99.0	124.6
	Total	1 297.2	1 467.4	1 638.6	1 980.3	1 297.2	1 467.4	1 638.6	1 980.3
Athabasca 3	Domestic	---	---	---	---	---	---	---	---
	Livestock	---	---	---	---	---	---	---	---
	Irrigation	---	---	---	---	---	---	---	---
	Total	---	---	---	---	---	---	---	---
BASIN TOTAL	DOMESTIC	2 867.6	2 767.8	2 668.6	2 474.4	2 867.6	2 767.8	2 668.6	2 474.4
	LIVESTOCK	12 790.6	14 850.2	16 909.5	21 031.2	12 790.6	14 850.2	16 909.5	21 031.2
	IRRIGATION	2 050.5	2 417.0	2 783.1	3 515.4	2 050.5	2 417.0	2 783.1	3 515.4
	TOTAL	17 708.7	20 035.0	22 361.2	27 021.0	17 708.7	20 035.0	22 361.2	27 021.0

NOTE: Data in this Table calculated from Tables 3, 10, 12 and 13. For all the agricultural purposes, it is assumed that quantities withdrawn are also consumed. Distribution of irrigation water uses for 1981 estimated on basis of number of projects in sub-basins and average value of 73.2 x 10^3m^3. For 1986 to 2001, irrigation estimates based on total increase and project percentage distribution by sub-basin components. Slight differences are due to rounding of figures.

indicate that this sub-basin will have the greatest agricultural water uses through the forecast period, followed by the La Biche, Lesser Slave, McLeod and Athabasca 2, and Athabasca 1 sub-basin components. In terms of percentage increases over the forecast period, the McLeod, Pembina and Athabasca 2 components all increased by 53 percent, the Athabasca 1 component by 51 percent, and the Lesser Slave and La Biche components by 48 percent each.

INDUSTRIAL WATER USE

General Characteristics

The Athabasca Basin has a concentration of highly valuable natural resources including timber, coal, petroleum and natural gas, oil sands and water (8). These resources present opportunities for a range of current activities and potential future developments which may have a considerable impact on the water resources in the basin. The location of the major non-renewable resource activities have been plotted on Figure 4. Significant developments have already taken place and further developments are now occurring, particularly extractive industry developments. The type, size, timing and extent of future industrial activities that may develop in the basin may be implied from the existing resources, but the size and timing are difficult to forecast. Industrial water use projections are therefore also difficult to make.

A review of industrial water use in the basin was undertaken and, according to data in Table 3, industry is the largest licensed water user. Allocations for 141 projects amount to 334 199.4 x $10^3 m^3$ annually or 85 percent of all allocations. Seventy-two projects are allocated 328 787.8 x $10^3 m^3$ from surface sources and 69 projects 5 411.6 x $10^3 m^3$ from groundwater sources. Data in Table 4 indicate that there are (1981) 8 industrial projects that are allocated 288 334.2 x $10^3 m^3$ annually directly from the Athabasca River. These 8 projects account for 86 percent of all industrial allocations. Industrial water allocations are expected to exceed all other allocations in the future.

Source: Energy Resources Conservation Board
1. Coal Regions, Designated Coal Fields, and Isolated Coal Deposits, 1980.
2. Designated Oil and Gas Fields and Oil Sands Deposits, Main Pipelines, Refineries and Gas Processing Plants, 1980
3. Personal Information ERCB Oil, Gas, Coal, Oil Sands Departments.

ATHABASCA RIVER BASIN

MAJOR NATURAL RESOURCES AND ACTIVITIES

FIGURE 4

TABLE 15

WATER USE BY INDUSTRY - ATHABASCA RIVER BASIN

($x\ 10^6 m^3$)

INDUSTRY	TOTAL INTAKE			GROSS USAGE			TOTAL DISCHARGED			TOTAL CONSUMPTION		
	1967*	1972	1976	1967*	1972	1976	1967*	1972	1976	1967*	1972	1976
Mining	22.9	34.5	66.8	n.a.	144.8	156.3	21.3	16.3	64.9	1.6	18.2	1.9
Manufacturing	33.5	36.0	31.4	n.a.	36.0	39.3	31.4	31.7	30.1	2.1	4.3	1.3
TOTALS	56.4	70.5	98.2	n.a.	180.8	195.6	52.7	48.0	95.0	3.7	22.5	3.2

Total recirculated in 1972 was 110.3

1976 was 97.4

NOTES: Alberta Industrial Water Use Surveys, 1976 and 1972.

Slight discrepancies in totals are due to rounding off.

* 1967 data obtained from Province of Alberta, Industrial Water Use Survey Athabasca, Red Deer, Peace River Basin, by Alberta Department of Industry and Tourism, July 1970.

An indication of the actual volume of water used by industry can be obtained from water use survey results (19), summarized in Tables 15 and 16.

TABLE 16

INDUSTRIAL WATER USE - BY SOURCE OF INTAKE AND POINT OF DISCHARGE ($\times 10^6 m^3$)

	YEAR	
SOURCE OF INTAKE SUPPLY	1972	1976
Public water system	0.009	0.027
Company surface system	70.322	97.816
Company groundwater system	0.168	0.200
Total	70.499	98.043
POINT OF DISCHARGE RETURN		
Public utility sewer	31.672	---
Surface waterbody	13.297	84.192
Ground (Well)	3.104	4.664
Transfer for re-use	.005	---
Total	47.988	88.856

NOTE: Alberta Industrial Water Use Survey, 1972 and 1976. Slight discrepancies in totals due to rounding off.

Of the plants that reported having a private water supply system in 1967, 39 percent withdrew water from wells and the rest from surface sources; only two plants used municipal water systems*.

The variety of potential future developments in the basin make industrial water use forecasts a very dubious undertaking. The natural resources in the basin are important in assessing

* The 1967 industrial water use information has been extracted from Province of Alberta, Industrial Water Survey Athabasca, Red Deer, Peace River Basin, by Alberta Department of Industry and Tourism, July 1970.

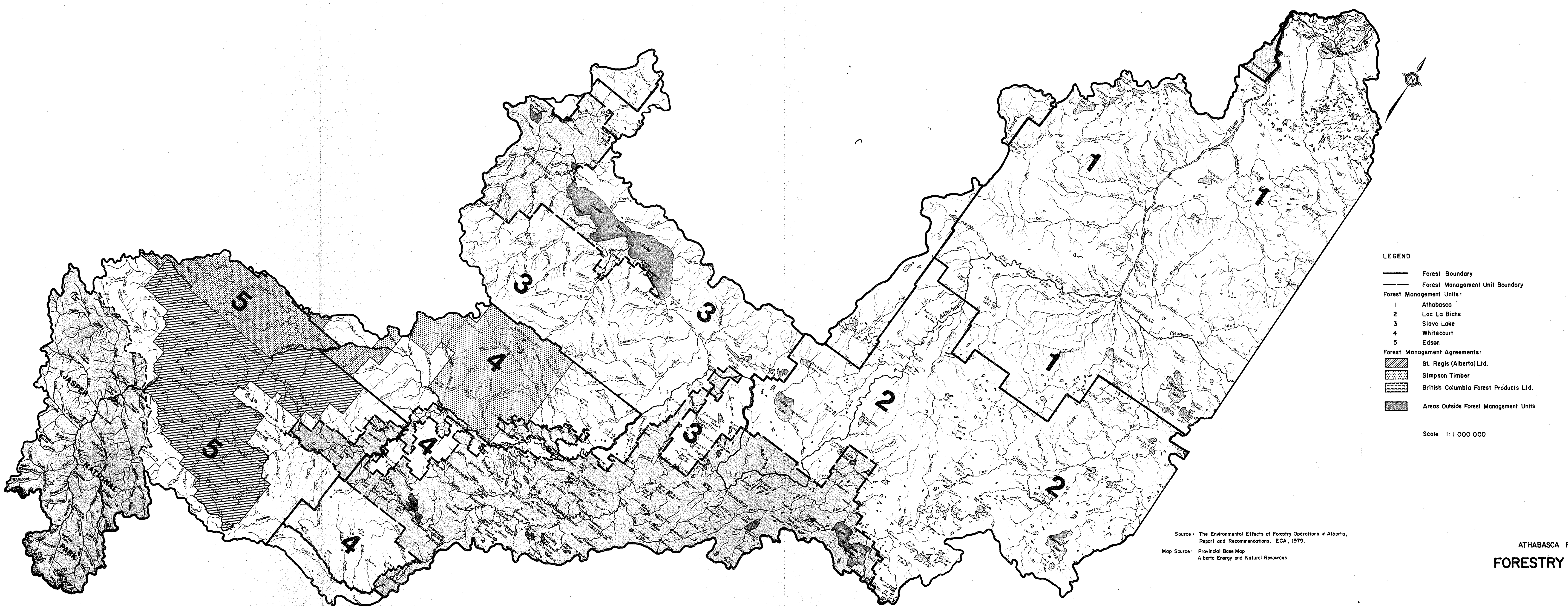
potential future industrial developments. Separate analyses of the various natural resources, corresponding industrial activities and water uses are dealt with in the following sections. It should be pointed out that due to the current economic conditions in Alberta, some large scale developments, particularly in the oil sands, that were scheduled to start have been either cancelled or postponed.

Forestry

Historical and Current

The basin area is mainly covered by forests as shown on Figure 5. Forest production dominates the land use patterns especially in the headwaters. Figure 5 illustrates that a major portion of the headwater region is included in a timber management agreement area (Edson forestry area) held by St. Regis (Alberta) Ltd. The timber produced from this area is utilized in an integrated bleached sulphate pulp mill and sawmill operated by St. Regis in Hinton. The pulp mill produces approximately 178 200 metric tons of Kraft pulp annually, and the sawmill operation produces studs and railway ties. The timber in the remaining forest areas provides raw material for the operation of numerous sawmills located throughout the basin. Neither timber harvesting nor sawmill operations use significant amounts of water.

The St. Regis plant is licensed to withdraw 84 300.0 x $10^3 m^3$ annually from the Athabasca River. The plant supplies water to the plant as well as to the Town of Hinton. According to the 1976 survey (19), water use at the plant is fairly constant over the year. Some indication of water use is given by the following data from survey results:



Source: The Environmental Effects of Forestry Operations in Alberta, Report and Recommendations. ECA, 1979.

Map Source: Provincial Base Map
Alberta Energy and Natural Resources

ATHABASCA RIVER BASIN

FORESTRY AREAS

FIGURE 5

Year	Intake	Discharge	Consumption
1972	36 000.0	31 700.0	4 300.0
1976	31 400.0	30 100.0	1 300.0

All units are in thousands of cubic metres.

Forecasted

For the forecast period, to the year 2001, water use at the St. Regis Ltd. plant is expected to be near current levels of use. It has been estimated that the plant will require an intake of about 33 200.0 x $10^3 m^3$, return 30 600.0 x $10^3 m^3$ or 92 percent and consume 2 600.0 x $10^3 m^3$ or 8 percent annually (9). Water use at the sawmill operation is minimal, and even with possible expansions in this operation in the future, its water requirements will remain negligible.

According to information from Environmental Assessment and Water Rights, another Kraft pulp mill on the scale of St. Regis' Hinton operation is being planned at Hurdy, west of Whitecourt (see Figure 4). Pulp and paper installations tend to use water-intensive production processes. The St. Regis plant in Hinton uses the Kraft process and requires about 190 m^3 of water per tonne. It is an older facility, however; more modern Kraft plants only need 45 to 65 m^3 of water per tonne of production*. Lacking firm information regarding potential water requirements, it is assumed that the plant near Hurdy will have a similar production capacity as the St. Regis plant, but its water use will be about 50 m^3 per tonne of production or

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* This range in values obtained from Water Use in the North Saskatchewan River Basin, by Canadian Resourcecon Ltd. for Planning Division, Alberta Environment, July 1982. Another range of values, 5 to 20 m^3 per tonne for the thermal-mechanical pulp technology are also mentioned. It is very likely that the new plant at Hurdy will use appreciably less water than the St. Regis plant at Hinton.

8 910.0 x 10^3m^3 of water annually and commence production by 1991. Furthermore, it is assumed that water consumption at the plant will be about 8 percent or less of gross withdrawals, approximately 712.8 x 10^3m^3 water annually.

A variety of timber products are produced by sawmills located throughout the basin. Water use at these operations is primarily for personnel and cleaning purposes, thus only minimal quantities are required. Simple intensification or expansion of current operations would not create large increases in water use. Considerable potential exists for more sawmills, but no projections are available. Although the number of sawmill operations may be expected to increase in the future, their water requirements will remain negligible and will only contribute slight increases to the industrial water use sector.

Coal

Historical and Current

The basin contains large coal resources that are subject to intensive exploration and development activity (see Table 17). There is a range in grades and potential uses of the coal deposits. Subbituminous coal beds suitable for thermal power generation and possibly for the manufacture of chemicals and synthetic fuels exist in the Plains region. Various types of bituminous coal suitable for metallurgical purposes are found in the Foothills and Rocky Mountain region.

Prior to 1959, the Coal Branch area was very productive. With recent renewed interest in coal, this area is receiving a lot of attention. The Coal Branch area extending from Luscar and Robb to Hinton has the highest potential (8). Results of exploration show proven

TABLE 17
ATHABASCA RIVER BASIN - COAL RESOURCES AND POTENTIAL DEVELOPMENT

FIELD Letters correspond to those on Figure 4	AREA OF INITIAL IN PLACE (sq km)	EXISTING MINES	TYPE OF MINE	RANK OF COAL	END USE OF COAL	WASH PLANTS		REMAINING RESERVES			POTENTIAL FOR INCREASE IN RESERVES	POTENTIAL PRODUCTION PERIODS	POTENTIAL INDUSTRIAL ACTIVITIES	POTENTIAL FOR SLURRY PIPELINE	VERY APPROXIMATE ANNUAL QUANTITIES OF COAL AND WATER: THERMAL POWER PLANT		COAL WASHING PLANT		GASIFICATION PLANT		LIQUEFACTION PLANT		SLURRY PIPELINE	
						EXISTING	FUTURE	SURFACE (Mt)	UNDERGROUND (Mt)	TOTAL (Mt)					COAL (Mt)	WATER ($10^6 m^3$)	COAL (Mt)	WATER ($10^6 m^3$)	COAL (Mt)	WATER ($10^6 m^3$)	COAL (Mt)	WATER ($10^6 m^3$)	COAL (Mt)	WATER ($10^6 m^3$)
Brule (A)	11.8	1 abandoned		Low and (perhaps) med. vol. bit.		No	Long term, and only if reserves increase	3	10	13	Slight?	21st Century	Wash plant (only if reserves increase, or in conjunction with some other deposit)				1	0.3						
Cadomin-Luscar (B)	30.4	1 producing 1 under construction 4 abandoned	Open pit Open pit	med. vol. bit.	Metallurgical (mainly Japan)	One	1 under construction	151	47	198	Moderate	present to 2030	2 wash plants				5	1.5						
Mountain Park (C)	9.4	1 abandoned		High B/or med. vol. bit.		No	Yes	37	15	52	High	1990's?	Wash plant				2	0.6						
Moberly Creek (D)	23.9			Bituminous		No	Long term and only if reserves increase	0	0	N.A.	Moderate	1990's?	Wash plant (only if reserves increase, or in conjunction with some other deposit)				1	0.3						
Pocahontas (E)	3.5	2 abandoned		Bituminous		No	No	0	0	N.A.	Slight													
Rock Lake (F)	7.9			Bituminous		No	No	0	0	N.A.	Slight													
Anderson Creek (G)	0.6	2 abandoned		High vol. bit.		No	Likely	0	6	6	High	1990's	Wash plant, possibly in conjunction with some other deposit	Fair (if reserves increase)			1	0.3					1	4
Coalspur (H)	48.5	1 producing 11 abandoned	Open pit	High vol. bit.	Export thermal (mainly Ontario)	One	No	143	132	275	High	present to 2050		Fair (if markets can be developed overseas)			4	1.2					1	4
Cold Creek (I)	7.5	1 abandoned		High vol. bit.		No	Likely	2	2	4	High	21st Century	Wash plant, possibly in conjunction with some other deposit	Fair (if reserves increase			1	0.3					1	4
Hannington (J)	59.5			probably high vol. bit.		No	Likely	143	25	168	Slight	1990's	Wash plant	Fair			3	0.9					3	12
Maxwell Lake (K)	1.5	1 abandoned		High vol. bit.		No	No	0	0	N.A.	Slight													
McLeod River (L)	40.6	1 abandoned 2or3 possible	Open pit	High vol. bit.	Export thermal	No	Yes (3-6)	235	16	251	High	1986-2050	3 to 6 wash plants	Good			10	3.0					10	40
Moose Lake (M)	0.7			High vol. bit.		No	Likely	1	2	3	High	21st Century	Wash plant, possibly in conjunction with some other deposit	Fair			1	0.3					1	4
Obed Mountain (N)	26.5	1 with permit granted but with construction deferred	Strip & open pit	High vol. bit.	Export thermal	No	Yes	98	12	110	Slight	1988-2020	Wash plant	Good			4	1.2					4	16
Peppers Lake (O)	18.1			High vol. bit.		No	Likely	0	0	N.A.	High	21st Century	Wash plant, possibly in conjunction with some other deposit	Fair			1	0.3					1	4
Thompson Creek (P)	10.0			High vol. bit.		No	Likely	15	13	28	High	21st Century	Wash plant, possibly in conjunction with some other deposit	Fair			2	0.6					2	9
Barrhead (Q)	282.6	1 abandoned		Sub-bit. C		No	No	64	18	82	Moderate, especially to SW in underground category	21st Century	Power Plant (1000 MW) Liquefaction Gasification } If reserves are expanded or in conjunction with other deposits		5.0	27			10	22-44	10	22		
Firebag (R)	14.3			Bitumen impregnated lignite A		No	No	0	36	36	Slight													
Fox Creek (S) (approx ½ S Brush Mtn Deposit)	61.0			Sub-bit. C		No	No	105	12	117	Slight, but considerable reserves in Kneekwap E&W just outside Athabasca B.	21st Century	Power Plant (2000MW) would require coal from just outside basin	Coal probably too low a quality	10.6[1]	57[2]								
Lesser Slave Lake (T)	90.8			Lignite A		No	No	38	0	38	Slight													
Mayerthorpe (U)	124.1	1 small producing mine 7 abandoned	Strip	Sub-bit. B	Domestic	No	Yes, if coal can be upgraded to export quality	77	17	94	High, especially to SW in underground category	21st Century	Wash Plant Liquefaction Gasification } If reserves are expanded	Possibly. Coal may need some form of upgrading			10-20	3-6	10	22-44	10	22	10C/W 20C/M	44 88
Morinville (V) (Manola & approx 1/3 each of Pickardville & George Lake)	141.0	1 producing 3 abandoned	Strip	Sub-bit. C	Domestic	No	No	72	16	88	Moderate, especially to SW in underground category	21st Century	Power Plant (1000 MW) Liquefaction Gasification } Would require some reserves from just outside Athabasca Basin.		4.6	25			10	22-44	10	22		
Sawridge Hill (W)	27.3	1 abandoned		Lignite A		No	No	0	7	7	Slight													
Swan Hills (X)	20.9			Sub-bit. C		No	No	0	0	0	Slight													
S. Swan Hills (Y)	332.0			Sub-bit. C		No	Possibly	300	98	398	Moderate	21st Century	Power Plant (2000 MW) Washing Plant (possibly in conjunction with liquefaction or gasification Liquefaction / Gasification	Slight. Coal would need upgrading	9.8[3]	53[4]	10-20	3-6	10	22-44	10	22	10C/W 20C/M	44 88
Wabamun (Z) (Stanger & Magnolia)	104.7	5 abandoned		Sub-bit. B		No	Yes, if coal can be upgraded to export quality	121	10	131	High, especially to SW in underground category	21st Century	Power Plant (2000 MW) Wash Plant Liquefaction Gasification	Fair. Coal may need upgrading	8.3[5]	45[6]	10-20	3-6	10	22-44	10	22	10C/W 20C/M	44 88

NOTES: Mountain Region: includes fields A to F
Foothills Region: includes fields G to P
Plains Region: includes fields Q to Z

C/W - coal/water
C/M - coal/methanol
Mt - metre tone

1. 14 with pyrolysis
2. 67 with pyrolysis
3. 13 with pyrolysis
4. 62 with pyrolysis
5. 11 with pyrolysis
6. 52 with pyrolysis

SOURCE: ERCB Coal Department - November 1981.

reserves in the Robb Block capable of supporting a projected 20-year production of 2.7 million metric tons annually (38).

Several companies have approval for coal mining activities in the Cardinal River, Lovett River, Luscar and other areas in the headwaters of the basin. The mining process itself does not utilize water unless special hydraulic mining techniques were adopted. According to Table 17, there are currently two operations that have some water requirements, particularly for washing of coal, which is carried out under controlled conditions. The ERCB data in Table 17 provides a value for annual water use for a coal washing plant estimated at about 300.0 x $10^3 m^3$ per million metric tons of coal processed. One company, Cardinal River Coals Ltd., is supplying 0.9 million metric tons of metallurgical coal annually to Japan on a 15-year contract. According to the 1976 Alberta Industrial Water Use Survey (19), the operation had in that year water withdrawals of about 279 265 m^3, consumption of 139 949 m^3 or 50 percent of withdrawals, and discharges of 139 316 m^3.

Forecasted

A) General Outlook: Regarding potential coal developments, the ERCB was contacted for an indication of the type of industrial activities that the coal reserves could support. The information summarized in Table 17 indicates that substantial coal reserves exist. The data on development potential are very speculative and should be looked at on an "either-or" basis. Estimates provided by the ERCB's Coal Department summarized in Table 18 provide a rough guide for both coal and water resource requirements for potential coal developments.

The ERCB estimates that there are sufficient deposits to support various coal-related industrial developments such as thermal power generation, washing plants, gasification, liquefaction and coal slurry pipeline operations. The coal reserves will likely increase as more detailed exploration activities occur, but the recoverable portions are approximated at 50 percent of the estimated reserves.

The Environmental Impact Assessment Branch of Alberta Environment provided information on anticipated industrial projects and noted that several companies are very active in the Foothills and Mountain regions of the basin; some have submitted preliminary disclosures of intended activities.

B) Coal Washing Plants: Depending on the potential reserves in various fields as shown by Table 17, there is the possibility of 21 wash plants ultimately operating in the basin some time beyond the year 2001. Based on the ERCB estimate*, the plants would have a total annual water requirement of 11 700 x $10^3 m^3$ for processing 39 million metric tons of coal. Consumptive water use, assumed to be 50 percent of withdrawal would amount to 5 850 x $10^3 m^3$ annually for all of the plants. Development of these washing plants would occur in the sub-basin components as shown in Table 19, with the McLeod sub-basin having the highest development potential.

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* ERCB estimate of 300.0 x $10^3 m^3$ of water annually per million metric tons of coal processed.

TABLE 18

COAL AND WATER REQUIREMENTS FOR POTENTIAL DEVELOPMENTS ATHABASCA RIVER BASIN

	RESOURCE REQUIREMENTS		
	COAL	NET WATER*	
POTENTIAL DEVELOPMENT	(10^6t/yr)	(m^3/s)	$10^6 m^3$/yr
Thermal Power Plant			
2000 MW	8-10	1.4-1.7	44.2-53.6
2000 MW + Pyrolysis	13	2.0	63.1
Coal Conversion			
Gasification	10	0.7-1.4	22.1-44.2
Liquefaction	10	0.7	22.1
Slurry Pipeline			
Coal/water	10	1.4	44.2
Coal/methanol	20	1.4-2.8	44.2-88.3

* Water requirement given does not include that required in coal preparation.

SOURCE: Energy Resources Conservation Board, Coal Department, November 1981.

TABLE 19

COAL WASHING PLANTS - COAL AND WATER REQUIREMENTS ATHABASCA RIVER BASIN (Ultimate Development)

SUB-BASIN COMPONENT	NO. OF PLANTS	COAL PROCESSED Mt/yr	WATER REQUIRED x $10^6 m^3$	WATER CONSUMED x $10^6 m^3$
Athabasca 1	5	5	1.5	0.75
McLeod	11	23	6.9	3.45
Berland	3	9	2.7	1.35
Pembina	2	2	0.6	0.30
TOTAL	21	39	11.7	5.85

SOURCE: Table 17.

C) Thermal Power Plants: Various views exist regarding the potential of the coal deposits, but it is generally agreed that there are adequate coal reserves to support thermal power plants with varying generation capacities. Table 17 provides resource requirement estimates for coal-related developments which could eventually be developed. A report prepared by the Electric Utility Planning Council* provides some information on the capacities and locations of potential coal-fired plants in the basin.

The water required for a thermal plant depends on many factors including type of cooling employed, climate, and quality of recycled water. According to Frey (44), all of the potential thermal power plants would utilize cooling ponds and would require make-up water from a nearby lake or river. For the purpose of this report, make-up requirements have been assumed to be 0.85 m^3/s (30 cfs) or 27 000.0 x $10^3 m^3$ water annually per 1000 MW plant**. Consumption estimates of 2 percent of total annual withdrawals, based on Alberta Industrial Water Use Survey, 1976 (19), were applied as indicated in Table 20. The potential coal-fired plants, their location, and estimated annual water requirements are listed in Table 20. According to that table, the Pembina sub-basin component has the highest potential, and thus would have the greatest impact on the water resources.

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* Power Generation in Alberta, 1981-2005 by the Electric Utility Planning Council, March 12, 1981.

** Estimates based on ERCB information.

TABLE 20

POTENTIAL THERMAL POWER PLANTS AND WATER USE
ATHABASCA RIVER BASIN

RIVER BASIN COMPONENT	PLANT NAME	CAPACITY MW	LOCATION	ESTIMATED ANNUAL WATER USE WITHDRAWALS 10^3m^3	ESTIMATED ANNUAL WATER USE CONSUMPTION 10^3m^3	REMARKS
Lesser Slave	Lesser Slave Lake	750	On the lake about 3 km west of the Town of Slave Lake.	20 000.0	400.0	
Athabasca 1	Judy Creek	2,250	About 60 km north of Whitecourt in the south Swan Hills area.	60 800.0	1,216.0	The Lesser Slave Lake report (14) discloses that cooling water would likely be obtained from the Freeman River and/or the Athabasca River.
	Fox Creek	750	About 25 km northeast of the Town of Fox Creek.	20 000.0	400.0	Although located just outside of the basin, the plant would likely obtain its cooling water from the Athabasca River.
Pembina	Pickardville	750	About 50 km northwest of Edmonton and about 10 km south of Westlock.	20 000.0	400.0	The plant would utilize a cooling pond and would withdraw water from the Pembina River. Because of the relatively low flow in the river during the winter months it is likely that a six-month pumping period would have to be adopted.
	Barrhead	1,000	Barrhead area.	27 000.0	540.0	This plant only possible if reserves are expanded. The most likely source of water for the plant would be the Pembina River. The plant would operate like the Pickardville plant.
	Isle Lake	1,500	Northwest of Wabamun on Isle Lake.	40 500.0	810.0	Although located just outside of the basin, the plant would likely obtain its cooling water from the Pembina River. The plant would also operate like the Pickardville plant.

SOURCES: Power Generation in Alberta, 1981-2005 by the Electric Utility Planning Council, March 1981.

Energy Resources Conservation Board (42).

Frey, J. R. "Water Requirements for Thermal Power Generation in Alberta." Paper presented to the 34th Annual Power Conference, Banff, June 1981.

Consumption estimates based on Alberta Industrial Water Use Survey (1976) results in which a 0.47% consumptive use was obtained for all thermal power plants. This is only for in-plant losses, and when evaporative losses would be taken into account, consumption could rise to 2% of total withdrawals. A 2% consumption rate was applied for the above plants.

All of the listed potential thermal power plants are not expected to come onstream until the 21st Century.

D) Gasification and Liquefaction: Potential gasification and liquefaction operations using coal as a feedstock will also have significant water requirements. The water demand for these operations varies depending on the selected process and chemical composition of coal. A review of relevant literature has indicated a wide variation in water/coal ratios as well as the amount of coal required for an optimum size gasification plant of 250 million standard cubic feet of gas per day.

Potential areas suitable for gasification and/or liquefaction plants are indicated in Table 17 (Fields Q, U, V, Y, and Z). Ten plants in total (5 gasification and 5 liquefaction) are possible with total water requirements of about 110 000.0-220 000.0 x $10^3 m^3$ for the former and 110 000.0 x $10^3 m^3$ for the latter. Although no consumptive water use estimates for such operations are available, water losses could be in the same proportion as those for thermal power plants.

E) Hydraulic Mining: Hydraulic mining is a relatively new underground mining technique that has been successfully used in somewhat similar conditions in southeastern British Columbia*. Cardinal River Coals Ltd. is determining areas in its Alberta coal holdings that might be hydraulically mined, and has proposed to utilize an underground hydraulic mining technique (9). The water

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* "Hydromining comes of age at Kaiser," by Dan Jackson, western editor, Coal Age. V. 87, No. 11, November 1980, P. 54-63.
In hydraulic mining, coal is extracted from panels by a water jet. The coal is dislodged from the solid face by high water pressure and volume. The water use in mining the coal also transports it as a slurry away from the face.

circuit is completely closed, carrying a working volume of about 137.4 x $10^3 m^3$. A small percentage of water is lost, and any make-up water is derived from either groundwater, surface water, or a combination of sources. Hydraulic mining is not expected to be a large water user in the basin, and if instituted will only contribute slight increases to industrial water use generally.

F) Slurry Pipeline: One coal-related industrial development that would require substantial quantities of water is a slurry pipeline for transporting coal. The technology for a coal/water slurry has been demonstrated commercially in warmer environments. The Black Mesa pipeline, for example, traverses desert terrain in Arizona*.

The Alberta Government has funded a study to investigate the technical feasibility of slurry pipelining coal from the Coalspur area to Kitimat, British Columbia**. The pipeline would extend over a distance of about 1 016 km and would transport between 10.2 and 18.2 million tonnes of coal per year. Annual water requirements for the operation have been estimated at 25 609.9 x $10^3 m^3$ to 45 695.7 x $10^3 m^3$ for slurry preparation and for emergency flushing purposes.

The study also indicates water requirements for a methanol pipeline transporting medium. For a 50/50 dry coal/methanol slurry, up to 10 tonnes (12 m^3) of water could be needed to manufacture methanol and

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* "How the coal slurry pipeline in Arizona is working," by Julian Josephson. Environmental Science and Technology, Volume 10, No. 12, November 1976, p. 1086-1087.

** Coal Slurry Pipeline Feasibility Study, 1981, for Alberta Economic Development, and Alberta Energy and Natural Resources, by Fluor Canada Limited, Calgary, November, 1981.

transport 1 tonne of coal. In a coal/water slurry system, only 1 tonne (1.2 m^3) of water is required per tonne of coal*. For the purpose of this report, the preceding annual water use estimates are assumed in Table 21, although higher estimates were provided by the ERCB in Tables 17 and 18. It is assumed that all of the slurry pipeline water would be consumed.

According to the ERCB (42), coal slurry pipelining appears to be very attractive especially if the carrier fluid is methanol which could be produced from gas or coal. The Board indicated that if coal were used to produce the methanol, the grade would likely be sub-bituminous, and could emanate from the Plains coal fields outside of the Athabasca Basin. As noted in Table 17, there are 12 potential areas where slurry pipelining could be implemented. Nine possible source areas in the Foothills region transporting an estimated total 24 million tonnes of coal and 97 000 x $10^3 m^3$ of water annually, and 3 source areas in the Plains region having a total annual water requirement of 132 000 x $10^3 m^3$ for a coal/water transporting medium and 264 000 x $10^3 m^3$ for a coal/methanol transporting medium. The foregoing estimates are based on separate pipelines transporting coal from the areas. Water

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* The study also points out that the area of water requirement for coal to methanol production is very controversial. Such plants can consume up to 10 tonnes of water for every tonne of methanol produced if conventional cooling towers are used. The use of a dry cooling system in place of a wet one could substantially reduce the water consumption. Other minor reductions could be made by treating and recycling the blowdown and miscellaneous use waters. Such modifications could reduce water consumption to 2-5 tonnes of water per tonne of methanol produced. Based on the state-of-the-art, the water requirements for coal to methanol conversion could be reduced to a level approaching that of a coal/water slurry.

requirements could be reduced by utilizing a gathering and transporting system as suggested in the aforementioned Alberta Government's funded study.

Summary

The coal reserves in the basin could support various coal-related developments. It is not possible to forecast the timing, size, type or location of developments but the probable effects of any one or a combination of the coal-related projects, in addition to other industrial projects, could have a significant impact on the water resources. On the basis of the existing resources, the prospect for any of the coal-related industrial developments could be possible in the future. Gasification and liquefaction plants would be the largest users of water, but slurry pipelines would have the largest consumptive uses. The location of the coal resources and market destinations make the slurry pipeline possibility rather dubious. The summary Table 21 indicates that with continuing developments occurring, further increases in water use will occur. The sub-basin components with the largest potential increases are the Pembina, Athabasca 1, Lesser Slave, and McLeod.

Hydro-Electric Generation

Historical and Current

The generation of hydro-electricity is an instream use of water and thus withdrawals would not occur unless an offstream storage system was utilized. At present, there are no hydro power plants in the basin.

TABLE 21

SUMMARY OF WATER USE FOR COAL RELATED DEVELOPMENTS
ATHABASCA RIVER BASIN
1981-2001

RIVER BASIN COMPONENT	PURPOSE	WATER USE (10^3m^3) ESTIMATED WITHDRAWALS 1981	1986	1991	2001*	ESTIMATED CONSUMPTION 1981	1986	1991	2001*
Athabasca 1	Coal Washing	---	---	900	1 500	---	---	450	750
	Thermal Power	---	---	---	80 800	---	---	---	1 620
	Gas. & Lique.	---	---	---	44 000	---	---	---	880
	Hydraulic Mining	---	---	---	---	---	---	---	---
	Slurry Pipeline	---	---	---	12 000	---	---	---	12 000
	Total	---	---	900	138 300	---	---	450	15 250
McLeod	Coal Washing	2 700	2 700	6 300	6 900	1 350	1 350	3 150	3 450
	Thermal Power	---	---	---	---	---	---	---	---
	Gas. & Lique.	---	---	---	---	---	---	---	---
	Hydraulic Mining	---	---	140	140	---	---	---	---
	Slurry Pipeline	---	1 200	2 400	12 120	---	1 200	2 400	12 120
	Total	2 700	3 900	8 840	19 160	1 350	2 550	5 450	15 570
Pembina	Coal Washing	---	---	---	600	---	---	---	300
	Thermal Power	---	---	---	87 500	---	---	---	1 750
	Gas. & Lique.	---	---	---	176 000	---	---	---	3 520
	Hydraulic Mining	---	---	---	---	---	---	---	---
	Slurry Pipeline	---	---	---	24 000	---	---	---	24 000
	Total	---	---	---	288 100	---	---	---	29 570
Berland	Coal Washing	---	---	900	2 700	---	---	450	1 350
	Thermal Power	---	---	---	---	---	---	---	---
	Gas. & Lique.	---	---	---	---	---	---	---	---
	Hydraulic Mining	---	---	---	---	---	---	---	---
	Slurry Pipeline	---	---	---	---	---	---	---	---
	Total	---	---	900	2 700	---	---	450	1 350
Lesser Slave	Coal Washing	---	---	---	---	---	---	---	---
	Thermal Power	---	---	---	20 000	---	---	---	400
	Gas. & Lique.	---	---	---	---	---	---	---	---
	Hydraulic Mining	---	---	---	---	---	---	---	---
	Slurry Pipeline	---	---	---	---	---	---	---	---
	Total	---	---	---	20 000	---	---	---	400
BASIN TOTAL	Coal Washing	2 700	2 700	8 100	11 700	1 350	1 350	4 050	5 850
	Thermal Power	---	---	---	188 300	---	---	---	3 770
	Gas. & Lique.	---	---	---	220 000	---	---	---	4 400
	Hydraulic Mining	---	---	140	140	---	---	---	---
	Slurry Pipeline	---	1 200	2 400	48 120	---	1 200	2 400	48 120
	TOTAL	2 700	3 900	10 640	468 260	1 350	2 550	6 450	62 140

NOTES: Data in table based on information presented in the coal sub-section, and Tables 17, 18, 19 and 20.

* The year 2001 implies sometime in the 21st Century.

Forecasted

Concerning future hydro-electric power generation, several potential sites have been identified*, but aside from preliminary site assessments no comprehensive detailed studies were completed. The ERCB's 1981 report notes that due to geologic, geotechnical and economic reasons, development of hydro-electric projects in the basin does not appear attractive at the present time. When the demand for electricity increases in the future, the identified sites are potential options for hydro power development.

Natural Gas

Historical and Current

The basin contains significant natural gas resources. Estimates place the total remaining gas reserves at approximately 314 364 x $10^6 m^3$ (41, 42). This amounts to nearly 18 percent of the total remaining gas reserves in the province. About 305 gas strike areas** have been identified (42). Much of the land in the basin has been allocated to long-term commitments for petroleum and natural gas developments, 52 percent in the headwaters portion alone (7). Most of the dispositions on the lands are for 25 years, with some additional ones committed to the short-term, primarily for exploration or experimental production.

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* The hydro-electric energy potential of Alberta, a preliminary appraisal, April 1973, and Alberta's Hydroelectric Energy Resources, May 1981, by Energy Resources Conservation Board.

** A gas strike area is one in which gas has been tested at rates greater than 0.65 x $10^3 m^3/d$ (20 x 10^3 cf/d) prior to September 30, 1979 and 1.0 x $10^3 m^3/d$ (35 x 10^3 cf/d) after that date. ERCB gas department gas strike map as of March 1981.

Data provided by the ERCB indicates that there are 36 sour gas plants and 33 sweet gas plants currently operating in 244 producing areas. These plants, together with areas having potential for gas development, have been plotted on Figure 4. Of the 36 sour gas plants, 7 recover elemental sulphur and therefore would likely have a moderate water requirement. The remaining 29 sour gas plants that do not recover sulphur, for the most part, would utilize a process that has a small water requirement. Water is required at the sulphur recovery plants mainly to provide steam to operate various boilers, vessels and equipment. Additional requirements of fresh water are for personnel needs. The 33 sweet gas plants do not require large volumes of water other than for personnel use. The waste water that is generated from the gas plants is in most instances reinjected underground along with any produced water.

According to the 1976 survey (19) there were 5 gas processing operations in the basin. Water use information for these has been summarized in Table 22. Most of these gas plants obtain their water from surface water sources; the Amoco plant at Windfall, however, utilizes 5 groundwater wells (42).

Gas processing plants are distributed widely throughout the basin, minimizing effects on the water resources. Generally, water requirements for gas plants are small in comparison to those for enhanced oil recovery schemes, coal-related operations and oil sands plants. Based on data from the Alberta Industrial Water Use Survey, the average annual quantity of water used by sour gas processing plants amounted to approximately

TABLE 22

GAS PROCESSING PLANTS WATER USE 1976 - ATHABASCA RIVER BASIN

OPERATOR	PLANT LOCATION	SOURCE OF WATER	ALLOCATED AMOUNT ($x\ 10^3m^3$)	TOTAL INTAKE ($x\ 10^3m^3$)	TOTAL DISCHARGE ($x\ 10^3m^3$)	TOTAL CONSUMPTION ($x\ 10^3m^3$)
Amoco Canada Petroleum Ltd.	Whitecourt	Groundwater	n.a.	117.3	65.7	51.6
Chevron Standard Ltd.	Kaybob south plant near Whitecourt	Athabasca River	2,096.1	1,146.0	468.2	677.8
Imperial Oil Ltd.	Judy Creek	Freeman Lake	n.a.	19.3	1.8	17.5
Hudson's Bay Oil and Gas Co. Ltd.	Edson	McLeod River	1,602.9	919.5	75.1	844.4
Chevron Standard Ltd.	Mitsue plant	Lesser Slave R.	5,400.5	3,970.9	3,970.9	nil
				from file 4,858.0	from file 542.5	4,315.5

NOTES: Operator, location, source, intake and discharge information obtained from Alberta Industrial Water Use Survey 1976 (19).
Allocated amount information from Water Rights Branch (9).

In the 1976 survey there were also additional smaller gas processing plants located in the Athabasca Basin that reported water use of less than 454.6 m^3/yr.

It should be noted that several gas plants are closely integrated with some companies' petroleum operations as well. That is, water used at a plant may be utilized, once discharged, for pressure maintenance purposes in enhanced oil recovery operations.

In 1976, the crude petroleum and natural gas industry in the Athabasca River Basin accounted for total intake of 66.5 x 10^6m^3 and total discharge of 64.8 x 10^6m^3. (19)

15.0 x $10^3 m^3$ per plant*. By utilizing the preceding figure, an annual total requirement of 540.0 x $10^3 m^3$ is derived for the 36 sour gas plants.

Forecasted

Regarding future gas developments, the ERCB has indicated a number of areas (see Figure 4) having potential for natural gas development. Given the plentiful natural gas reserves, it can be assumed that additional gas processing plants will be located in the potential gas development areas, but no indication of the number of additional plants, their timing, or likely locations are provided. Furthermore, the sources of water that would be used and gross requirements for potential plants are also not provided. Indications from current operations are that no serious impact on surface water sources will occur as the most likely source for most plants would be groundwater. With the foregoing in mind, water use by sour natural gas processing plants has been summarized in Table 23.

Aside from exploratory drilling in many areas, development drilling which is extending productive areas of existing pools is also occurring (42). The reserves are continually reviewed and re-evaluated principally on the basis of new data and performance. The ERCB has indicated that an area of intense exploration activity is located just north of the basin in Townships 58-60, Ranges 1-6, west of the 6th Meridian. This activity may extend south into Township 57 (the Berland sub-basin component), but further south the zones become very poor reservoirs and would not likely be target for exploration. The ERCB estimates that large discoveries in the Foothills area could increase the reserves of the basin by 15-20 percent.

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* Water Use and the Natural Gas Processing Industry, by Planning Services Branch, Planning Division, Alberta Environment, 1979. The data in the report pertains only to natural gas processing plants that reported to have used 4 546 m^3 of water or more in the 1976 survey.

TABLE 23

WATER USE BY GAS PROCESSING PLANTS - ATHABASCA RIVER BASIN

	ESTIMATED WATER USE ($10^3 m^3$)											
	ESTIMATED WATER WITHDRAWALS								ESTIMATED WATER CONSUMPTION			
RIVER BASIN COMPONENT	# OF GAS PLANTS	1980	# OF GAS PLANTS	1986	# OF GAS PLANTS	1991	# OF GAS PLANTS	2000	1980	1986	1991	2000
Athabasca 1	7	105.0	7	105.0	8	120.0	10	150.0	68.3	68.3	78.0	97.5
Athabasca 2	9	135.0	9	135.0	10	150.0	12	180.0	87.8	87.8	97.5	117.0
McLeod	4	60.0	4	60.0	4	60.0	6	90.0	39.0	39.0	39.0	58.5
Pembina	9	135.0	9	135.0	10	150.0	12	180.0	87.8	87.8	97.5	117.0
Lesser Slave	6	90.0	6	90.0	7	105.0	8	120.0	58.5	58.5	68.3	78.0
La Biche	1	15.0	1	15.0	1	15.0	2	30.0	9.8	9.8	9.8	19.5
BASIN TOTAL	36	540.0	36	540.0	40	600.0	50	750.0	351.2	351.2	390.1	487.5

NOTES:
1. Sources for tabulated data are ERCB and Water Use and the Natural Gas Processing Industry, by Planning Services Branch, Planning Division, Alberta Environment, 1979.
2. Only sour gas plants are considered.
3. Assumed increase in total number of sour gas plants, and distributed in most active gas producing areas: total of 4 by 1991 and 10 plants by 2001.
4. Average withdrawal of 15 x $10^3 m^3$/year/plant, from (1) above.
5. Average consumption of 65% of withdrawals per plant, based on (1) above.

Petroleum - Water Flood Schemes

Historical and Current

The basin contains significant reserves of petroleum resources, including crude oil recovered by conventional methods and oil sands recovered by either surface mining or in-situ methods. Similar potential development opportunities exist for the petroleum resources as those indicated for the natural gas resources. The basin contains an estimated 46 percent of total reserves of light-and-medium and heavy crude oil reserves in the province (41). As exploratory work is completed and detailed information becomes available, additional areas may be ascertained to have potential producing capabilities, thereby increasing the reserves.

There are approximately 36 oil fields partially or wholly in the basin, and these contain 195 enhanced oil recovery operations* utilizing water flood schemes (41, 42). The ERCB's Oil Department indicated that

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* Fluid is often injected into oil reservoirs to supplement the natural pressure available, and usually results in a substantial increase in the amount of crude oil ultimately recovered - sometimes by as much as 50% of the oil in place. Such schemes are classed as enhanced-recovery projects. Water is most commonly used because it is technically and economically most attractive in the majority of pools in Alberta, while solvent injection consisting of liquefied petroleum gases and natural gas is the second most common. (Amoco, for example, in the South Swan Hills field is operating a solvent flood project that has produced between 9 000 b/d and 14 000 b/d, The Oil and Gas Journal, V. 76, #37, September 11, 1978, p. 40). ERCB Conservation in Alberta, 1976.

The Athabasca River Basin contains water flooding projects in which a water-drive, enhancing the secondary-recovery operation of oil, has been effectively established. It can be assumed that the productivity of the oil pools will be maintained with this process (41, 42).

Some of the water flood schemes that have reached a mature state are being subjected to detailed technical reassessment that results in modifications to schemes such as the addition or changing of injection wells (9).

most of the pools in the basin are currently subject to water flood operations (42). Some of the fields are shown on Figure 4. According to an OGWU-DAC printout, September 1980, there was a total of 280 schemes, 268 utilizing groundwater sources and 12 surface sources. Of this total, 85 had either no injection or were phased out, thus reducing the operating water flood schemes to 195.

According to Water Rights' data summarized in Table 24, there are 63 active licensed conventional water flood projects. This includes 15 projects for which no allocations were given, and 48 injection schemes with a total allocation of 58 259.4 x $10^3 m^3$, 54 246.9 x $10^3 m^3$ or 93 percent allocated from surface water and 4 012.6 x $10^3 m^3$ from groundwater sources. Data obtained from selected water use returns contained in the Water Right's project files, summarized in Table 25, illustrate some actual amounts of water use by water flood schemes.

All water flood methods require the use of large volumes of water, all of which is assumed to be consumed and not available for other uses. Water flood schemes accounted for a total of 235.8 x $10^6 m^3$ of water used, 89 percent from surface water and 11 percent from groundwater sources during the past 8 years (see Table 26). The total annual average water use for all injection projects amount to 29.5 x $10^6 m^3$ or 2.5 x $10^6 m^3$ per month. Due to the high assumed consumption rates, some concern was voiced in early 1980 regarding the groundwater resources of the Pembina oilfield area (9). The following was extracted from a ministerial memorandum in response to that concern.

> "In a 1976 report dealing with groundwater resources in the Pembina oil field area it was estimated that the total recharge (the amount of rainfall reaching the water table and available for extraction by wells) was being 27.4 x $10^6 m^3$ or about 6000 million gallons annually. During 1971, the year held to be one in which groundwater produc-

TABLE 24

ACTIVE INJECTION PROJECTS - ATHABASCA RIVER BASIN

	NO OF PROJECTS			ALLOCATED QUANTITY (m^3)		
SUB-BASIN COMPONENT	S	GW	NA	S	GW	TOTALS
Pembina	4	22	15	1 221 164	3 992 830	5 213 994
McLeod	1	--	--	863 450	--	863 450
Athabasca 1	9	1	--	34 424 517	19 736	34 444 253
Lesser Slave	11	--	--	17 737 730	--	17 737 730
Sub-Total	25	23	15	54 246 861	4 012 566	58 259 427
Athabasca 2	1	--	--	1 356 850	--	1 356 850
Athabasca 3	1	3	3	18 502	71 542	90 044
Clearwater	2	7	2	631 552	483 532	1 115 084
Sub-Total	4	10	5	2 006 904	555 074	2 561 978
GRAND TOTAL	29	33	20	56 253 765	4 567 640	60 821 405

NOTES: Source is Water Rights Branch computer printout of active licensed projects in Athabasca River Basin, September 1981.
The ERCB points out that the Pembina, McLeod, Athabasca 1 and Lesser Slave sub-basin components contain conventional water flood type projects, while the Athabasca 2 and 3 and Clearwater sub-basin components contain experimental in-situ recovery injection projects.

TABLE 25

WATER USE FOR ENHANCED OIL RECOVERY OPERATIONS - ATHABASCA RIVER BASIN

Applicant	Gross Annual Allocated Quantity (x $10^6 m^3$)	Source of Supply	Annual Water Use (x $10^6 m^3$) 1972	1973	1974	1975	1976	1977	1978	1979	1980	Future Trends
Home Oil	8.8	Swan River	--	3.6	5.7	5.1	5.1	4.3	3.2	--	--	declining
Mobil	3.3	Carson Creek	--	--	--	--	--	--	--	2.3	2.8	declining
Amoco	11.3	Freeman Lake	--	6.5	6.5	5.1	5.2	6.9	7.0	7.9	8.2	declining
Esso Resources Canada Ltd	14.7	Athabasca River to Carson Lake	6.4	7.9	9.6	6.5	3.8	6.1	5.3	4.6	--	constant
Shell Canada Resources	2.5	Coulee	1.3	2.1	2.6	1.9	1.7	1.0	0.9	0.8	1.1	constant
Norcen Energy Resources Ltd	0.12	Pembina River	--	0.08	0.10	0.06	0.06	0.08	0.06	0.06	0.08	declining
Chevron Standard	5.4	Lesser Slave R.	3.3	--	--	3.1	3.3	3.5	--	3.4	3.7	declining

NOTES: Source - Water Rights Project files, Water Use returns.

TABLE 26

WATER INJECTION 1972-1979 - ATHABASCA RIVER BASIN
($10^6 m^3$)

SOURCE	1972*	1973	1974	1975	1976	1977	1978	1979	TOTAL
Groundwater	3.8	4.5	4.0	3.1	2.6	2.4	2.4	2.4	25.2
Surface	16.4	33.4	31.5	27.6	24.9	27.7	25.4	23.7	210.6
TOTAL	20.2	37.9	35.5	30.7	27.5	30.1	27.8	26.1	235.8

SOURCE: ERCB microfiche of water used in secondary oil recovery schemes. Planning Division, Alberta Environment, Oil and Gas Water Use by Drainage Area Codes (OGWU-DAC) computer printout.

*It should be noted that values for 1972 are only partial values. If these values were excluded, the cumulative total would be 21.4 for groundwater, 194.2 for surface water and 215.6 for grand total. The annual average would then amount to 30.8 or 2.6 per month.

The OGWU-DAC data indicates that 26 991.4 x $10^3 m^3$ of water was used for injection in 1980.

tion for enhanced recovery purposes in the Pembina field reached its maximum the total groundwater produced for this purpose was 7.2 x $10^6 m^3$ or about 1600 million gallons. The groundwater resources in the Pembina oil field are therefore under no long term threat."

Forecasted

The amount of water used in the future for secondary oil recovery schemes depends on a number of factors including costs of schemes, estimates of recoverable oil, geological structure of oil bearing strata, and the price of oil. In reviewing Water Rights' files, it was noted that in the future many projects do not anticipate any large change in quantities used for injection while others anticipate a steadily declining use to the year 2000. Enhanced recovery schemes account for about one-third of Alberta's conventional crude-oil recovery, and with continuously decreasing resources, the importance of augmenting reserves through recovery of a higher fraction of oil in place increases*.

Regarding future water use for conventional water flood schemes in the basin, the ERCB's Oil Department has prepared a forecast, Table 27, which is applicable only to those pools that are currently subject to water flooding. It does not account for additional flooding of other pools or new discoveries. In generating the forecast, several assumptions were made:

a) All produced water is reinjected.

b) Only solution gas is being produced.

c) Withdrawals at reservoir conditions are replaced by water injection at a ratio of 1:1.

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* G. C. Watkins. "Costs of supply: Oil enhanced-recovery schemes in Alberta." Bulletin of Canadian Petroleum Geology, V. 25, No. 2, (May 1977), P. 433.

TABLE 27

WATER REQUIREMENTS - m^3/DAY
CONVENTIONAL WATER FLOOD SCHEMES
ATHABASCA RIVER BASIN

Lesser Slave	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Mitsue Gilwood A	8580	8580	8580	7385	6356	5470	4708	4052	3485	3003	2583	2224	1914	1647	1418	1221	1051	904	779	671
Swan Hills BHL A&B	11450	10517	9660	8873	8150	7486	6876	6316	5800	5328	4894	4495	4129	3792	3484	3199	2939	2699	2479	2277
Swan Hills BHL C	2368	2197	2038	1891	1754	1628	1510	1401	1300	1205	1119	1038	963	893	829	769	713	662	614	570
Sub-Total	22398	21294	20278	18149	16260	14584	13094	11769	10585	9536	8596	7757	7006	6332	5731	5189	4703	4265	3872	3518
Annual ($10^6 m^3$)	8.2	7.8	7.4	6.6	5.9	5.3	4.8	4.3	3.9	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.7	1.6	1.4	1.3
McLeod																				
Carrot Creek Card G&F	18	60	60	60	54	49	44	40	36	33	30	27	24	22	20	18	16	14	13	12
Niton Basal Quartz B	265	265	265	265	265	265	265	265	239	216	196	177	161	145	131	119	108	97	88	80
Sub-Total	283	325	325	325	319	314	309	305	275	249	226	204	185	167	151	137	124	111	101	92
Annual ($10^3 m^3$)	103.3	118.6	118.6	118.6	116.4	114.6	112.8	111.3	100.4	90.9	82.5	74.5	67.5	61.0	55.1	50.0	45.3	40.5	36.9	33.6
Pembina																				
Pembina Cardium	8774	7991	7303	6675	6101	5575	5096	4658	4256	3889	3555	3249	2969	2714	2481	2267	2071	1893	1731	1581
Bigoray Ostracod	77	77	77	77	77	67	56	49	42	36	31	27	23	20	17	15	13	12	--	--
Cherhill Banff	286	286	286	286	286	286	286	259	234	213	194	176	161	147	135	124	114	105	98	91
West Pembina Area	5700	5700	5700	4905	4222	3633	3128	2693	2318	1994	1716	1478	1270	1095	942	812	698	600	518	446
Cyn Pem Cardium A	302	260	223	193	166	143	123	105	91	78	68	59	50	43	37	32	27	23	20	16
Sub-Total	15139	14314	13589	12136	10852	9704	8689	7764	6941	6210	5564	4989	4473	4019	3612	3250	2923	2633	2367	2134
Annual ($10^6 m^3$)	5.5	5.2	5.0	4.4	4.0	3.5	3.2	2.8	2.5	2.3	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.8
Other																				
Carson Creek N BHL A	1677	1488	1320	1171	1037	921	816	724	642	569	504	449	397	353	313	277	246	218	193	172
Carson Creek N BHL B	3526	3159	2829	2535	2271	2035	1822	1632	1462	1310	1173	1052	942	844	755	678	606	543	486	436
Judy Creek BHL A	7246	6557	5933	5368	4858	4394	3977	3598	3256	2946	2666	2412	2182	1975	1788	1616	1463	1324	1198	1083
Judy Creek BHL B	3571	3229	2923	2644	2393	2165	1958	1774	1603	1452	1314	1187	1075	974	880	796	720	652	590	534
Judy Creek S BHL	67	55	44	36	29	24	20	16	13	11	10	8	7	5	3	3	3	--	--	--
Virgina Hills BHL	2100	1899	1719	1555	1407	1274	1152	1043	944	854	722	699	632	572	517	468	424	384	347	315
Swan Hills S BHL	10000	9048	8187	7408	6703	6065	5490	4966	4493	4066	3679	3329	3012	2725	2466	2231	2019	1827	1653	1496
Sub-Total	28187	25435	22955	20717	18698	16878	15235	13753	12413	11208	10068	9136	8247	7448	6722	6069	5481	4948	4467	4036
Annual ($10^6 m^3$)	10.3	9.3	8.4	7.6	6.8	6.2	5.6	5.0	4.5	4.1	3.7	3.3	3.0	2.7	2.5	2.2	2.0	1.8	1.6	1.5
TOTAL	66007	61368	57147	51327	46129	41480	37327	33591	30214	27203	24454	22086	19911	17966	16216	14645	13231	11957	10807	9780
Annual Total ($10^6 m^3$)	24.1	22.4	20.9	18.7	16.8	15.1	13.6	12.3	11.0	9.9	8.9	8.0	7.3	6.6	5.9	5.3	4.8	4.4	3.9	3.6

SOURCE: ERCB Oil Department, November 1981.
NOTE: Schemes in "Other" actually fall into the Athabasca 1 region.

d) The current formation volume factor was used in forecasting future requirements. The formation volume factor varies considerably throughout the basin and, with time, will fluctuate somewhat due to varying pressure levels. The net effect of b) and c) would be to give a slightly conservative estimate of water requirements, particularly in view of the calculations based on a 1:1 ratio.

Past reviews by the ERCB's Oil Department have indicated that provincially, about 20 percent of total fresh water usage was from groundwater sources. However, in the Athabasca Basin, only about 10 percent of total water use for water flood schemes is obtained from groundwater sources, the remaining 90 percent is derived from surface sources. It is assumed that these percentages will remain relatively constant in the future.

If the preceding assumptions are realized, withdrawals of water for injection in the basin as demonstrated by Table 27 could experience a decrease from 24.1 x $10^6 m^3$ in 1981 to 3.6 x $10^6 m^3$ by 2000.

The forecast does not incorporate any additional water flooding that may be attributed to a growth in reserves. The ERCB does not maintain a forecast of new discoveries specifically for the basin. However, the Board points out that the West Pembina area in the basin has the greatest potential for additional water flooding.

Petroleum - Oil Sands

Historical and Current

A) Surface Mining: The largest non-renewable resource in the basin that currently accounts for large volumes of water in its extraction, and probably will continue to have a considerable impact on the water resources in the basin in the future is the Athabasca Oil Sands deposit.

The Athabasca Oil Sands deposit is the largest one of four major oil sands deposits in Alberta. The evaluated oil sands area covers some 43 600 km^2 in the northeast part of the basin (29) (see Figure 4). The ERCB considers only 38 400 km^2 of this as having development potential. About 2 000 km^2 of the deposit is overlain by 75 metres or less of overburden and is amenable to surface mining (4).

The ERCB estimated the initial volume of crude bitumen in-place for the Athabasca deposit at about 137 billion m^3 (41). "Within the ultimate potential mining area on Figure 4, the initial in-place volume of ultimate potential mineable crude bitumen was estimated to be 12.1 billion m^3. The initial established reserves of 5.2 billion m^3 of crude bitumen were determined. By assuming a recovery factor of 0.75, the initial established reserves of synthetic crude oil for the surface-mineable areas of the Athabasca Wabiskaw-McMurray Deposit accordingly would be 3.9 billion m^3," (41). The Athabasca Oil Sands deposit thus contains adequate reserves to support several commercial scale synthetic crude extraction operations.

There are currently 2 commercial scale plants (Suncor and Syncrude) capable of producing 24 000 m^3 (150 000 barrels) per day. Both operations use surface mining methods to remove the oil sands. The mined material is conveyed to a bitumen extraction and upgrading processing plant where the bitumen and sand are separated by hot water.

According to Water Rights' data, a total of $192.9 \times 10^6 m^3$ of water is allocated annually to both operations from the Athabasca River. Actual annual quantities of water used for the two plants are summarized in Table 28 along with water use data for some experimental in-situ projects. Indications from annual water use returns (9) are that approximately 20 percent or less of total withdrawals may be consumed.

At the present time, the major users of water associated with oil sands developments are existing full-scale surface based oil sands mining plants and experimental in-situ pilot plant operations. Groundwater resources are generally insufficient to meet the requirements of large full-scale operations and their use is limited to experimental in-situ plants. Over 99 percent of the required water is obtained from the Athabasca River, which likely will be the main source of supply for future oil sands plants. As more and more plants are added to the full development of the oil sands, water use from the Athabasca River will increase considerably.

B) In-Situ Extraction: There are about 36 400 km^2 of the Athabasca Oil Sands deposit where the oil sands vary considerably in quality and are buried at such depths that the crude bitumen can only be recovered by in-situ extraction or some other method (4). The overburden thickness is a most critical factor to development because it influences the type of bitumen recovery methods utilized and costs (40). The Alberta Oil Sands Technology and Research Authority (AOSTRA) and industry are involved in pilot plant projects distributed throughout the oil sands area testing a variety of in-situ processes, but a commercially applicable method has not yet been developed. One in-situ process currently proposed for commercial application requires tremendous quantities of water, estimated at 52.3 x $10^6 m^3$ annually, composed of 33.9 x $10^6 m^3$ of fresh water make-up and 18.4 x $10^6 m^3$ of recycled water*. Consumption for the process is estimated at 33.9 x $10^6 m^3$ or 65 percent of annual withdrawals.

According to data in Table 24, there are 14 experimental in-situ projects with a total allocation of 2 562.0 x $10^3 m^3$ annually, 2 006.9 x $10^3 m^3$ or 78 percent from surface water sources and 555.1 x $10^3 m^3$ or 22 percent from groundwater sources. An indication of actual quantities of water used by some in-situ pilot projects is provided in Table 28.

Most in-situ techniques involve injection of a fluid into the deposit to reduce the viscosity of the bitumen. The most readily available, least expensive, and easiest to handle are air and water. One estimate for a steam injection system for a 1 000 000 barrels per day bitumen production places water requirements at 10.3 m^3/s (16). Another estimate places the requirements at 1.4 m^3/s for an in-situ plant with a daily production of 160 000 barrels (32). One other source (35) mentions a figure of 80 m^3/ minute (1.3 m^3/s) for an in-situ scheme producing 100 000 barrels of synthetic crude per day.

"In-situ experimental activity in the province continues to be high and the level of activity is increasing. The ERCB is reasonably confident that the recovery technology to permit

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* Esso Resources Canada Ltd. Fresh Water Supply for Esso Resources Cold Lake Project. January, 1979.

TABLE 28

WATER USE FOR ATHABASCA OIL SANDS PROJECTS
ATHABASCA RIVER BASIN

PROJECT OPERATOR AND END USE OF WATER	GROSS ANNUAL ALLOCATED QUANTITY m^3	SOURCE OF SUPPLY	ANNUAL ACTUAL WATER USE m^3								
			1972	1973	1974	1975	1976	1977	1978	1979	1980
Amoco (steam injection)	483,532	Groundwater (7 wells)	--	--	--	--	--	74,276	116,925	236,859	407,174
Suncor (sands processing)	59,800,500	Athabasca River	--	--	· · · · · · · average of 163,656 m^3/day · · · · · · · · · · ·						59,629,000
Petro Canada (steam injection)	18,495	Slough	--	--	--	--	--	--	--	11,344	13,686
Syncrude (sands processing)	131,931,000	Athabasca River	--	--	--	--	450,000	13,737,615	40,604,816	46,099,057	40,135,000
Syncrude (municipal services)	1,200,000	Athabasca River	--	--	--	220,000	460,000	430,000	630,000	--	--
Texaco Canada Inc. (steam injection)	369,900	Saline Creek	94,000	91,900	117,600	80,800	174,500	232,500	194,800	117,900	--
Union Oil of Canada Ltd. (steam injection)	71,514	Groundwater	--	--	--	--	--	10,604	10,635	39,456	37,730

NOTES: Sources for above are: 1) Water Rights Branch, Alberta Environment, files, reports, computer printout . . .
2) References #19, 28 are additional sources.

All the above are currently in operation in oil sands deposit area. There are several other projects that are in planning stages and for which no data was available.

sustained production of crude bitumen in certain higher-quality areas of the oil sands deposits is available. However, due to environmental constraints and economic uncertainties, the ERCB is not in a position to attribute established reserves to any of the selected areas at this time" (41).

Forecasted

A) Surface Mining: One large factor to be considered in the further development of the oil sands concerns water, its availability, disposal, and effects on the environment. The ERCB has expressed concern over the volumes of fresh water used, and the necessity for large tailings ponds currently inherent in the Clark hot water process and encourages the commercial development of alternate bitumen extraction techniques (6). AOSTRA (29) is supporting research directed towards protecting the environment including methods to reduce consumption of water in various recovery processes.

There is little doubt that most of the recovery processes will result in some oil production, but how much, for how long, at what rate, under what conditions, and at what cost are critical unknowns (31). For any one full scale scheme, whether it be surface mining or in-situ extraction, significant quantities of water are required.

Future water use by potential oil sands projects depends upon the industrial growth and development that will occur. At this point in time, due to the prevailing economic uncertainties, some of the large scale developments that were scheduled to start have been either cancelled or shelved. It appears that industrial growth is a definite certainty with the extraction of bitumen from the oil sands deposit receiving continued attention. Production in the Athabasca Oil Sands area is expected to peak sometime in the first quarter of the 21st Century when several surface mining plants and in-situ extraction plants are expected to be in operation (see Table 29). The size of future projects and the technology employed are unpredictable, but the water requirements for the projects are anticipated to increase in the long term. In addition, availability of capital and labour, the long lead time required to plan a large project and to obtain all the necessary regulatory approvals, the rate of discovery of conventional crude oil and the international price will all influence the number of plants that will be constructed in the future*.

Some insights into future water requirements may be gained from commercial scale projects currently operating or being planned. Both Suncor's and Syncrude's operations provide water use information that could be assumed to apply to similar surface mining plants. The Alsands project's water requirements over a 25-year expected life period have been estimated at 2.02 m^3/s for the first three years of operation and then 0.90 m^3/s for years 4 to 25**. The fresh water requirements will be reduced in the latter years because water will be recycled. The ERCB estimates the Alsands project's requirements at 1.6 m^3/s as shown in Table 29.

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* Esso Resources Canada Ltd. Final Environmental Impact Assessment for Esso Resources Canada Ltd. Cold Lake Project, Volume III, Socio-Economic Impact Assessment, October, 1979.

** Application to the Alberta Energy Conservation Board for an Oil Sands Mining Project, by Alsands Project Group. December 1978.

TABLE 29

OIL SANDS COMMERCIAL PLANTS AND WATER REQUIREMENTS
ATHABASCA RIVER BASIN

OPERATION	OIL SAND DEPOSIT	LOCATION	EXPECTED START-UP	EXPECTED PLANT RETIREMENT	ANTICIPATED PRODUCTION ($10^3 m^3/d$)	TOTAL SYNTHETIC CRUDE PRODUCTIVE CAPACITY (10 m^3/d)	ESTIMATED WATER REQUIREMENT		
							(m^3/s)	($10^3 m^3/d$)	($10^6 m^3/yr$)
Suncor	Athabasca	92-10W4M	Operating	2000	10	10	1.2	103.7	37.8
Syncrude	Athabasca	93-11W4M	Operating	2010	21	31	1.6	138.2	50.5
Alsands	Athabasca	95-10W4M	1989	2020	21	52	1.6	138.2	50.5
Canstar	Athabasca	--	1992	2022	22	74	1.7	146.9	53.6
Shell	Peace River	86-16W5M	1991	2021	12	86	0.3	25.9	9.5
SM-5	Athabasca	--	1996	2026	22	108	1.7	146.9	53.6
SM-6	Athabasca	--	2004	2034	22	130	1.7	146.9	53.6
SM-7	Athabasca	--	2012	2042	22	142	1.7	146.9	53.6

NOTES: SM - surface mining plant

ERCB Processing Section, Oil Sands Department, November 1981.

It should be noted that the table does not include potential in-situ developments in the Athabasca Oil Sands deposit. The Shell development in the Peace River deposit is one in-situ operation which would withdraw water from the Athabasca River Basin.

An indication of potential oil sands surface mining commercial operations and corresponding water requirements is provided in Table 29 which is based on the following assumptions (42):

1) Production is assumed to level off after 2012 with plants being retired at approximately the same rate as new plants start up.
2) The forecast assumes that the Alsands project will come onstream in the 1988/89 period.
3) Subsequently, Canstar and Shell are assumed to come onstream some 3 years later and thereafter new plants commence production at 4-year intervals.
4) Surface mining and in-situ projects are assumed to alternate.
5) Projects in the Athabasca deposity and perhaps the Peace River deposit would withdraw water from the Athabasca River.
6) The locations of projects up to 1990 are known and given in Table 29. Thereafter, surface mining projects are assumed to be located in the surface mineable area of the Athabasca deposit (see Figure 4), and in-situ projects distributed more widely in the oil sands area.
7) Water requirements for forecast projects, given in Table 29, are based on operating experience at the Syncrude and Suncor plants in the case of surface mining projects, and on design information for the Cold Lake project in the case of the Peace River in-situ project.

8) Technology developments, that is, use of alternative extraction or upgrading processes may result in significant reductions in water requirement but none are sufficiently advanced at this time to depend on.

On the basis of Table 29, withdrawal requirements for 5 anticipated surface mining operations by the late 1990's are estimated at 246.0 x $10^6 m^3$ of water annually, 49.0 x $10^6 m^3$ of which would be consumed. By 2020, the water use is estimated at 264.9 x $10^6 m^3$ annually, 53.0 x $10^6 m^3$ of which would be consumed.

B) In-Situ Extraction: According to the ERCB, about 95 percent of the Athabasca Oil Sands area is considered to have potential for in-situ extraction operations. Since no reserve estimates for the deep oil sands deposits are available, it is difficult to attempt to determine the possible number of in-situ extraction plants that could be constructed, or the extraction method that could be utilized. The design information for the Cold Lake project may be indicative of potential water use for in-situ projects. One source (Humphrey's Engineering, 32) determined that on the basis of current technology it could be feasible for 5 in-situ plants to withdraw from the Athabasca River a total of about 95.0 x $10^6 m^3$ of water annually, 62.0 x $10^6 m^3$ of which would be consumed. The withdrawals and consumptive water uses for these projects would be in addition to other major withdrawals.

It appears that with further intensive developments occurring in the oil sands area, particularly in the Athabasca 3 and Clearwater sub-basin components, substantial increases in annual water use could take place. The potential levels of oil sands developments will have a considerable effect on the water resources in the basin, more than any other industrial developments.

Summary

Industrial water uses are summarized in Table 30. Indications are that industrial water withdrawals will rise from an estimated total of 178.16 x $10^6 m^3$ in 1981 to 1 004.15 x $10^6 m^3$ beyond the year 2001, an increase of 464 percent. Industrial water consumption is forecast to rise from 51.9 x $10^6 m^3$ in 1981 to 202.4 x $10^6 m^3$ over the forecast period, an increase of nearly 290 percent.

Oil sands operations, consistently the major industrial water users, account for an average of 65 percent of all industrial water withdrawals over the study period, followed by forestry, injection, coal and gas processing. By 2001, oil sands operations will account for 49 percent of total withdrawals and coal-related activities 47 percent. The largest withdrawals are forecast for coal-related activities, increasing over 17 000 percent, followed by oil sands operations with 316 percent. Coal-related activities have the largest increase in consumptive water uses, 4 500 percent over the forecast period. The largest water use increases are forecast to occur firstly in coal-related developments, and secondly in oil sands extraction activities. Although quantities of water used for oil well injection purposes are forecast to decrease steadily, new reserve discoveries combined with a greater emphasis on enhanced recovery schemes may result in a more gradual declining trend than forecasted.

Although the data in Table 30 indicate that the Athabasca 3 sub-basin component has the greatest industrial water uses, the Pembina

TABLE 30

SUMMARY OF INDUSTRIAL WATER USE - ATHABASCA RIVER BASIN

RIVER BASIN COMPONENT	PURPOSE	WATER USE ($10^6 m^3$) ESTIMATED WITHDRAWALS 1981	1986	1991	2001*	ESTIMATED CONSUMPTION 1981	1986	1991	2001*
Berland	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	0.90	2.70	---	---	0.45	1.35
	Gas Processing	---	---	---	---	---	---	---	---
	Injection	---	---	---	---	---	---	---	---
	Oil Sands	---	---	---	---	---	---	---	---
	Total	---	---	0.90	2.70	---	---	0.45	1.35
McLeod	Forestry	---	---	---	---	---	---	---	---
	Coal	2.70	3.90	8.84	19.16	1.35	2.55	5.55	15.57
	Gas Processing	0.06	0.06	0.06	0.09	0.04	0.04	0.04	0.06
	Injection	0.10	0.11	0.08	0.03	0.10	0.11	0.08	0.03
	Oil Sands	---	---	---	---	---	---	---	---
	Total	2.86	4.07	8.98	19.28	1.49	2.70	5.67	15.66
Pembina	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	288.10	---	---	---	29.57
	Gas Processing	0.14	0.14	0.15	0.18	0.09	0.09	0.10	0.12
	Injection	5.50	3.50	2.00	0.80	5.50	3.50	2.00	0.80
	Oil Sands	---	---	---	---	---	---	---	---
	Total	5.64	3.64	2.15	289.08	5.59	3.59	2.10	30.49
Lesser Slave	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	20.00	---	---	---	0.40
	Gas Processing	0.09	0.09	0.11	0.12	0.06	0.06	0.07	0.08
	Injection	8.20	5.30	3.10	1.30	8.20	5.30	3.10	1.30
	Oil Sands	---	---	9.50	9.50	---	---	6.18	6.18
	Total	8.29	5.39	12.71	30.92	8.26	5.36	9.35	7.96
La Biche	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	---	---	---	---	---
	Gas Processing	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.02
	Injection	---	---	---	---	---	---	---	---
	Oil Sands	---	---	---	---	---	---	---	---
	Total	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.02
Clearwater	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	---	---	---	---	---
	Gas Processing	---	---	---	---	---	---	---	---
	Injection	---	---	---	---	---	---	---	---
	Oil Sands	---	---	---	19.00	---	---	---	12.40
	Total	---	---	---	19.00	---	---	---	12.40
Athabasca 1	Forestry	33.20	33.20	42.11	42.11	2.60	2.60	3.37	3.37
	Coal	---	---	0.90	138.30	---	---	0.45	15.25
	Gas Processing	0.11	0.11	0.12	0.15	0.07	0.07	0.08	0.10
	Injection	10.30	6.20	3.70	1.50	10.30	6.20	3.70	1.50
	Oil Sands	---	---	---	---	---	---	---	---
	Total	43.61	39.51	46.83	182.06	12.97	8.87	7.60	20.22
Athabasca 2	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	---	---	---	---	---
	Gas Processing	0.14	0.14	0.15	0.18	0.09	0.09	0.10	0.12
	Injection	---	---	---	---	---	---	---	---
	Oil Sands	---	---	---	---	---	---	---	---
	Total	0.14	0.14	0.15	0.18	0.09	0.09	0.10	0.12
Athabasca 3	Forestry	---	---	---	---	---	---	---	---
	Coal	---	---	---	---	---	---	---	---
	Gas Processing	---	---	---	---	---	---	---	---
	Injection	---	---	---	---	---	---	---	---
	Oil Sands	117.60	120.00	170.50	460.90	23.50	24.00	34.10	126.58
	Total	117.60	120.00	170.50	460.90	23.50	24.00	34.10	126.58
BASIN TOTAL	Forestry	33.20	33.20	42.11	42.11	2.60	2.60	3.37	3.37
	Coal	2.70	3.90	10.64	468.26	1.35	2.55	6.45	62.14
	Gas Processing	0.56	0.56	0.61	0.75	0.36	0.36	0.40	0.50
	Injection	24.10	15.11	8.88	3.63	24.10	15.11	8.88	3.63
	Oil Sands	117.60	120.00	180.00	489.40	23.50	24.00	40.28	132.76
	TOTAL	178.16	172.77	242.24	1004.15	51.91	44.62	59.38	202.40

SOURCES: Data in summary table based on information presented by Tables 21, 23, 27, 28 and 29 in industry section as well as text.

* The year 2001 implies potential development some time in the 21st Century.

sub-basin component is estimated to have the largest rise in water withdrawals, increasing over 5 000 percent over the study period.

ATHABASCA BASIN SUMMARY

Current Water Use Levels, 1981

The Athabasca River Basin is subject to a variety of intensive resource development activities in which the use of water is an important factor. In order to provide the Basin Planner with data on various water use aspects, a water use study was carried out, the results of which are presented in this report. The summary Table 31 provides estimates of total current and forecasted levels of water use for municipal, agricultural and industrial sectors in sub-basin components of the basin. The numbers in the table have been derived by summing the estimates compiled separately for each type of water use.

Municipal Water Use: Municipal water use ranked third behind industrial and agricultural uses. Total municipal water use amounted to 12.40 x $10^6 m^3$ or 6 percent of total water withdrawals. Consumptive uses for this sector were 2.48 x $10^6 m^3$ or 3 percent of total consumption. Areas where municipal water withdrawals account for a large portion of sub-basin component totals are the La Biche (21 percent), McLeod (18 percent) and Athabasca 2 (16 percent).

Agricultural Water Use: Agricultural water use ranked second, accounting for 17.71 x $10^6 m^3$ withdrawn and consumed, or 9 percent of total withdrawals and 25 percent of total consumption. Areas where agricultural water use accounts for a large proportion of sub-basin component totals are the La Biche (79 percent), Athabasca 2 (76 percent) and the Pembina (59 percent).

TABLE 31

SUMMARY OF WATER USE BY SUB-BASIN COMPONENTS - ATHABASCA RIVER BASIN

SUB-BASIN COMPONENT	PURPOSE	ALLOCATION	WATER USE ($10^6 m^3$) ESTIMATED WITHDRAWALS 1981	1986	1991	2001*	ESTIMATED CONSUMPTION 1981	1986	1991	2001*
Berland	Municipal	---	---	---	---	---	---	---	---	---
	Agricultural	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Industrial	---	---	---	0.90	2.70	---	---	0.45	1.35
	Total	0.01	0.01	0.01	0.91	2.71	0.01	0.01	0.46	1.36
McLeod	Municipal	6.19	0.94	1.24	1.61	2.47	0.19	0.25	0.32	0.49
	Agricultural	0.20	1.30	1.47	1.64	1.98	1.30	1.47	1.64	1.98
	Industrial	6.24	2.86	4.07	8.94	19.28	1.49	2.70	5.67	15.66
	Total	12.63	5.10	6.78	12.19	23.73	2.98	4.42	7.63	18.13
Pembina	Municipal	2.46	1.89	2.32	3.02	4.64	0.38	0.46	0.60	0.93
	Agricultural	1.11	10.82	12.24	13.66	16.52	10.82	12.24	13.66	16.52
	Industrial	5.45	5.64	3.64	2.15	289.08	5.59	3.59	2.10	30.49
	Total	9.02	18.35	18.20	18.83	310.24	16.79	16.29	16.36	47.94
Lesser Slave	Municipal	0.34	1.17	1.39	1.81	2.78	0.23	0.28	0.36	0.56
	Agricultural	0.05	1.35	1.53	1.71	2.07	1.35	1.53	1.71	2.07
	Industrial	17.73	8.29	5.39	12.71	30.92	8.26	5.36	9.35	7.96
	Total	18.12	10.81	8.31	16.23	35.77	9.84	7.17	11.42	10.59
La Biche	Municipal	0.38	0.47	0.62	0.80	1.24	0.09	0.12	0.16	0.25
	Agricultural	0.06	1.80	2.05	2.29	2.67	1.80	2.05	2.29	2.67
	Industrial	0.18	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.02
	Total	0.62	2.29	2.69	3.11	3.94	1.90	2.18	2.46	2.94
Clearwater	Municipal	0.04	---	---	---	---	---	---	---	---
	Agricultural	---	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Industrial	1.13	---	---	---	19.00	---	---	---	12.40
	Total	1.17	0.01	0.01	0.01	19.01	0.01	0.01	0.01	12.41
Athabasca 1	Municipal	6.65	2.67	3.40	4.43	6.80	0.53	0.68	0.89	1.36
	Agricultural	0.19	1.11	1.26	1.40	1.68	1.11	1.26	1.40	1.68
	Industrial	115.87	43.61	39.51	46.83	182.06	12.97	8.87	7.60	20.22
	Total	122.71	47.39	44.17	52.66	190.54	14.61	10.81	9.89	23.26
Athabasca 2	Municipal	0.91	0.28	0.31	0.40	0.62	0.06	0.06	0.08	0.12
	Agricultural	0.55	1.30	1.47	1.64	1.98	1.30	1.47	1.64	1.98
	Industrial	1.36	0.14	0.14	0.15	0.18	0.09	0.09	0.10	0.12
	Total	2.82	1.72	1.92	2.19	2.78	1.45	1.62	1.82	2.22
Athabasca 3	Municipal	8.78	4.98	6.18	8.05	12.36	1.00	1.24	1.61	2.47
	Agricultural	---	---	---	---	---	---	---	---	---
	Industrial	186.21	117.60	120.00	170.50	460.90	23.50	24.00	34.10	126.58
	Total	194.99	122.58	126.18	178.55	473.26	24.50	25.24	35.71	129.05
BASIN TOTAL	Municipal	25.76	12.40	15.45	20.12	30.91	2.48	3.09	4.02	6.18
	Agricultural	2.83	17.71	20.04	22.36	27.02	17.71	20.04	22.36	27.02
	Industrial	334.17	178.16	172.77	242.24	1 004.15	51.91	44.62	59.38	202.40
	Total	362.76	208.27	208.26	284.72	1 062.08	72.10	67.75	85.76	235.60

SOURCES: Water use figures obtained from Tables 8, 14 and 30 for municipal, agricultural and industrial purposes, respectively.

Slight differences are due to rounding of figures.

* The year 2001 is considered to mean forecasted beyond 2001 based upon known resource potential, particularly with respect to industrial developments.

Industrial Water Use: Industrial water use is presently the largest water user. Total withdrawals amounted to 178.16 x $10^6 m^3$ or 86 percent, and consumptive uses amounted to 51.91 x $10^6 m^3$ or 72 percent of total consumption. The Athabasca 3 and 1 sub-basin components have the largest proportion of industrial use, 96 and 92 percent respectively, followed by the Lesser Slave (77 percent), the McLeod (56 percent), and the Pembina (31 percent).

The Athabasca River is an important source for many users, but especially for large industrial operations. It is estimated that about 76 percent of the water used is obtained from the main stem of the river, 22 percent from major tributaries and other surface sources, and the remaining 2 percent from groundwater sources.

Future Water Use Levels, 1981-2001

Municipal Water Use: Total municipal water withdrawals and consumption are forecast to increase 149 percent. The level of use is expected to increase to 30.91 x $10^6 m^3$ or 3 percent of total water use by the year 2001, shifting municipal water use into second place. Consumptive uses by the municipal sector average about 4 percent of total for the 1981 to 2001 period. The proportion of municipal water use in each sub-basin component are forecast to be fairly constant over the study period. The McLeod sub-basin component is expected to have the greatest percentage growth in municipal water use, an increase of 163 percent. The Athabasca 1 component ranked second with a growth of 155 percent, followed closely by the Athabasca 3 and Pembina sub-basins with 148 and 146 percent, respectively.

Agricultural Water Use: Agricultural water use is anticipated to grow 53 percent from 17.71 x $10^6 m^3$ in 1981 to 27.02 x $10^6 m^3$ in 2001. This increase is expected to be insignificant in comparison to industrial water use increases. In the year 2001, agricultural uses will comprise only 3 percent of total withdrawals and 11 percent of total consumption. Consumptive uses by the agricultural sector average about 27 percent of total for the period 1981 to 1991 but decline to the aforementioned lower level by 2001. Livestock watering in the agricultural sector influences its general water use behavior. The Pembina sub-basin component was found to have a consistently high agricultural water use proportion during the study period.

Industrial Water Use: Industrial water withdrawals are expected to increase nearly 500 percent from 178.16 x $10^6 m^3$ in 1981 to 1 004.15 x $10^6 m^3$ in 2001. Consumption is anticipated to increase nearly 300 percent from 51.91 x $10^6 m^3$ in 1981 to 202.40 x $10^6 m^3$ in 2001. Industrial water consumption averages at 69 percent of total for the 1981 to 1991 period but rises sharply to 86 percent of total consumption in 2001.

In the year 2001, the largest industrial water uses are anticipated to occur in the Athabasca 3, Pembina and Athabasca 1 components. Industrial water withdrawals are forecast to rise over 5 000 percent in the Pembina, 574 percent in the McLeod, 317 percent in the Athabasca 1 and 292 percent in the Athabasca 3 components.

In view of the economic uncertainty, large scale industrial projects being developed in the near future in the basin appear to be doubtful. The potential natural resources are present, and should any intensive development in the basin occur, the requirements for water would increase considerably.

Total water withdrawals in the basin could reach a level of 284.72 x $10^6 m^3$ and consumption 85.76 x $10^6 m^3$ in the 1990's. If one were to speculate further and consider all the potential ultimate development possibilities sometime beyond the year 2001, an annual total requirement of 1 062.08 x $10^6 m^3$ could result, with an estimated total of 235.60 x $10^6 m^3$ of water being consumed.

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