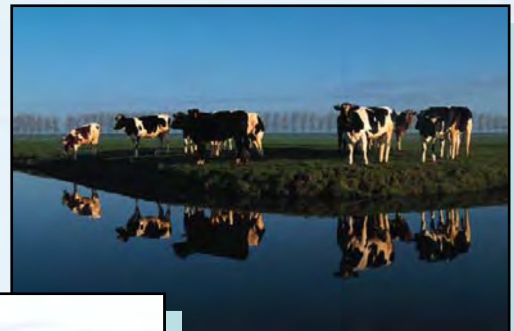
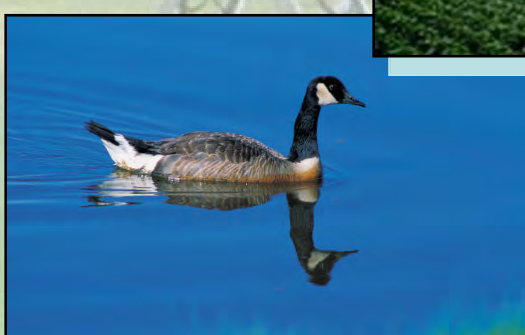
MUNICIPAL DISTRICT OF ACADIA No. 34
IRRIGATION DEVELOPMENT STUDY
Final Report - Volume I of II
June, 2005





Prepared by:

mpe ENGINEERING LTD.

MUNICIPAL DISTRICT OF ACADIA No. 34
IRRIGATION DEVELOPMENT STUDY

Final Report

VOLUME I of II

2280-001-00

PERMIT TO PRACTICE
MPE ENGINEERING LTD.
PERMIT NUMBER: P 3680
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

PROFESSIONAL ENGINEER
M. J. Breuning
ALBERTA
June 10/05

Prepared by:

MPE Engineering Ltd.

June 2005

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P.O. Box 30
No. 9 Main Street
Acadia Valley, Alberta
T0J 0A0

June 09, 2005
File:N:\22\80\001\00\L01-1.0

Attn: Mr. Gary Peers
Chief Administrative Officer

Dear Sir;

Re: Municipal District of Acadia No. 34
Irrigation Development Study

We are pleased to submit the final report for the M.D. of Acadia No. 34 Irrigation Development Study. The report presents the findings of a conceptual engineering study, examining the feasibility of developing a viable and sustainable irrigation project within the southern portion of the M.D. of Acadia. Comments and suggestions received on the "Draft" report have been accommodated in the "Final" report. As requested, the final report was bound in two volumes:

Volume 1 – Final Report
Volume 2 – Appendices

We appreciate the opportunity to undertake this study and look forward to continuing work on this project and with the M.D. of Acadia.

Yours truly,

MPE ENGINEERING LTD.

Mike Breunig, P. Eng.
Senior Project Manager

MB/bl

Encl.

VOLUME I of II

TABLE OF CONTENTS

TABLES

CHARTS

FIGURES

VOLUME II (Separate Cover)

ACKNOWLEDGEMENTS

MPE and the study participants gratefully acknowledge the assistance of all members of the Project Committee. Throughout the study, the committee members provided background information, input and direction.

The Project Committee consisted of the following members:

Name	**Organization**
Larry Heeg	M.D. of Acadia No. 34 (Reeve)
Gary Peers	M.D. of Acadia No. 34 (CAO)
Wally Chinn	Alberta Agriculture, Food and Rural Development
Brian Taylor	Alberta Agriculture, Food and Rural Development
Trevor Helwig	Alberta Agriculture, Food and Rural Development
Randy Poon	Alberta Environment
Ryan Davison	Agriculture and Agri-Food Canada, PFRA
Jeff Printz	Agriculture and Agri-Food Canada, PFRA

In addition to the Project Committee, following organizations are also gratefully acknowledged for providing staff and assistance with various aspects of the project:

Organization	**Assistance**
Palliser Regional Services	Providing digital mapping and aerial photography on behalf of the MD.
AAFRD	Digitizing the Land III Classification maps; and Providing updated IDM modelling for the proposed irrigation development
Alberta Environment	Providing water license information; and Completing SSRB modelling simulations.
PFRA	Providing the digital terrain model
MD of Acadia No. 34	Providing air photos and stereoscope; and Providing reports and anecdotal information

EXECUTIVE SUMMARY

Background:

At the request of the Municipal District of Acadia No. 34 (MD), a Project Committee was established to facilitate a study of "Irrigation Development" within the MD. The committee consisted of funding partners and representatives from the MD; Alberta Agriculture, Food and Rural Development (AAFRD); Alberta Environment (AENV); and Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada.

The Municipal District of Acadia No. 34 is one of the regions in Alberta most severely impacted due to a lack of precipitation, secure water supply and economic growth and diversification. Agriculture is the predominant industry in the area. A change from dryland to irrigation farming could stabilize farm incomes, provide employment opportunities through the enhancement of new support industries and improve overall social conditions in the area. Earlier studies, carried out in the mid-1980's, examined water supply alternatives for both municipal and irrigation purposes. However; the benefit/cost ratios were less than favourable and further investigations were not implemented.

Since the mid-1980's, development of the Valley South Water Co-op, and the implementation of privately operated irrigation systems on irrigable land near the Red Deer River within the MD, has significantly impacted project parameters for the potential irrigation projects studied in the 1980's. In addition, advances in irrigation infrastructure, conveyance efficiency and pressurized irrigation distribution systems have also been made.

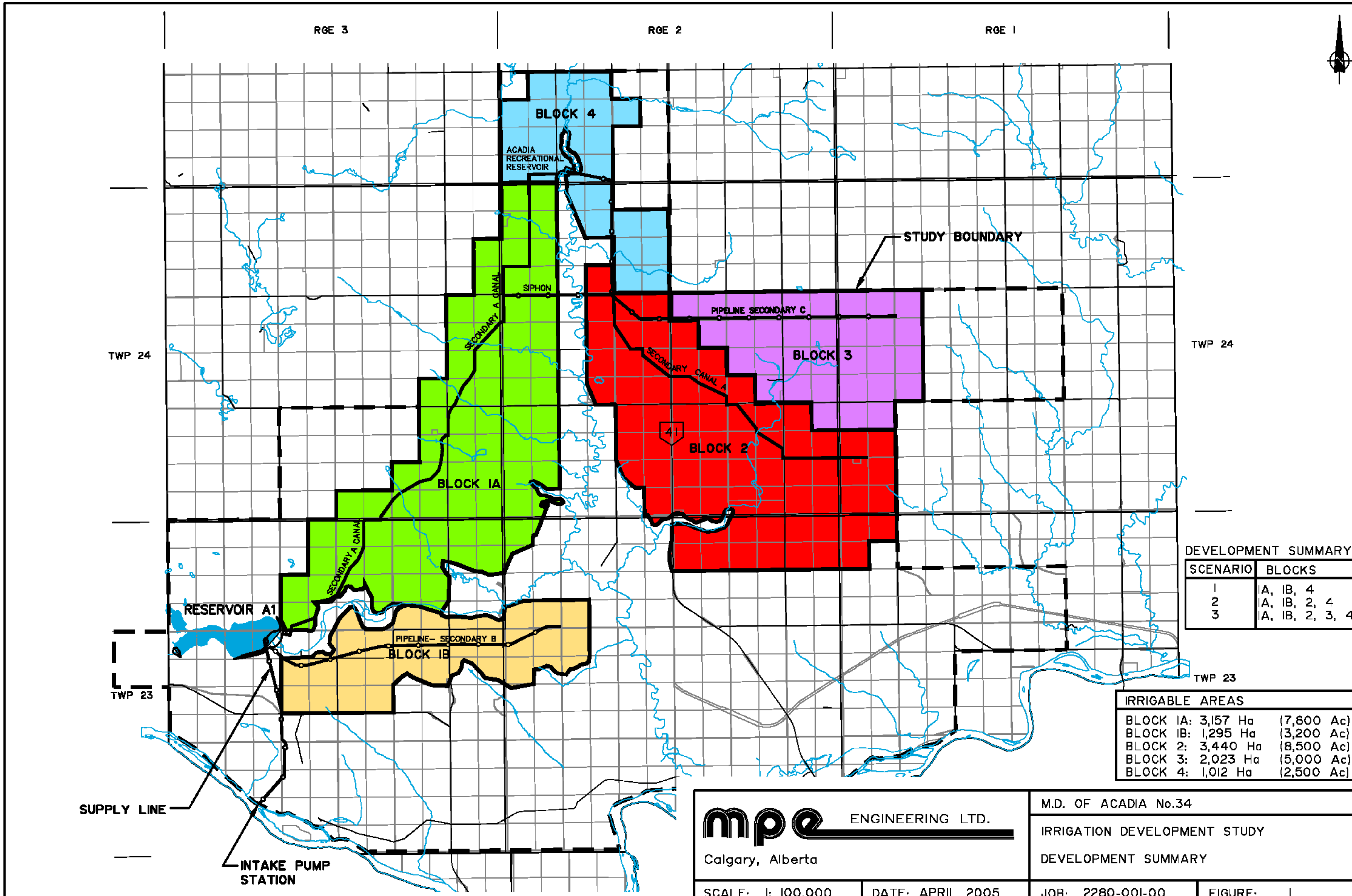
As a result of these changes and the continuing challenges of an unsecured water supply to the area, the Project Committee assigned MPE Engineering Ltd. (MPE), to undertake an up-to-date Conceptual Engineering Study, to examine the feasibility of developing a viable and sustainable irrigation project within the southern portion of the MD.

Methodology:

The determination of the irrigation blocks for this study was made in collaboration with the project Project Committee and took into account land classification, system infrastructure requirements and water availability from the Red Deer River. Three irrigation development scenarios were selected within the study area, utilizing Class 2 & 3 lands, as follows:

Scenario 1	5,500 ha (13,600 acres)
Scenario 2	8,904 ha (22,000 acres)
Scenario 3	10,927 ha (27,000 acres)

Refer to Figure 1 for the selected irrigation blocks and development scenarios.



DEVELOPMENT SUMMARY

SCENARIO	BLOCKS
1	IA, IB, 4
2	IA, IB, 2, 4
3	IA, IB, 2, 3, 4

IRRIGABLE AREAS		
BLOCK IA:	3,157 Ha	(7,800 Ac)
BLOCK IB:	1,295 Ha	(3,200 Ac)
BLOCK 2:	3,440 Ha	(8,500 Ac)
BLOCK 3:	2,023 Ha	(5,000 Ac)
BLOCK 4:	1,012 Ha	(2,500 Ac)

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Calgary, Alberta

M.D. OF ACADIA No.34

IRRIGATION DEVELOPMENT STUDY

DEVELOPMENT SUMMARY

SCALE: 1: 100,000 | DATE: APRIL 2005 | JOB: 2280-001-00 | FIGURE: 1

Irrigation demand modelling by AAFRD determined that the overall average On-Farm irrigation demand is 393 mm/ha (15 inches of water per irrigated acre), with the range being 200 to 535 mm/ha (8 to 21 inches per acre). Detailed WRMM modelling was completed both for the project and the Red Deer River (AENV's SSRB model), to optimize diversion rate and off-stream storage requirements with water availability from the River

The WRMM modelling determined that the annual irrigation demand deficit was 100mm or greater, 8.8% of the time, based on a 68 year model of the period of record from 1928 to 1995. The total number of deficit years (any amount of annual deficit) was fairly consistent for all the scenarios, with Scenario 2 being the least at 11 years and Scenario 3 being the most at 14 years.

Table 1 provides a summary of the diversion and storage requirements determined for each development scenario:

Table 1

Scenario	River Diversion		Off-Stream Storage	
	Rate	Mean Annual Volume	Live	Total
1	2 m^3/s	21,200 dam^3	8,000 dam^3	13,500 dam^3
2	4 m^3/s	36,100 dam^3	12,300 dam^3	17,800dam^3
3	4 m^3/s	43,200 dam^3	17,000 dam^3	22,500dam^3

Proposed Development:

Various infrastructure alternatives were assessed as part of an initial optimization process, leading to the proposed infrastructure developed for the three development scenarios, as shown on Figure 1.

The proposed development utilizes pumped diversion water from a single diversion site on the Red Deer River, to an off-stream storage reservoir (Reservoir A1) located in an un-named tributary to Kennedy Coulee. The majority of the development (Blocks 1A, 1B, & 2), will be gravity fed from the storage reservoir via a lined canal (Secondary A) and a closed pipeline (Secondary B). Irrigation water for Blocks 3 & 4 will be gravity fed via Secondary A canal, to the existing Acadia Recreational Reservoir, and then pumped via a pressurized delivery system. All delivery laterals will be pipelines. Gravity delivery systems will run to the irrigation parcel, while pressurized systems (Blocks 3 & 4), will supply water to the centre of the pivot with adequate pressure to negate on-farm pumping.

Table 2 provides the capital and annual O&M costs for the three development scenarios:

Table 2

	Scenario 1	Scenario 2	Scenario 3
Total Capital Cost*	$54,600,000	$79,100,000	$96,100,000
Capital Cost per Irrigated Acre	$4,015	$3,595	$3,559
Annual O & M Cost	$1,650,000	$2,430,000	$2,860,000

* 2004 dollars

Conclusions / Recommendations:

Based on a Water Conservation Objective of 50% IFN, there is sufficient water available in the Red Deer River for all three development scenarios, based on an accepted weighted average annual crop deficit of 100mm or greater, no more than 10% of the time.

Environmental and water quality impacts of the proposed development exist, but do not appear to be severe. The impacted areas from an environmental perspective, primarily relate to Reservoir A1 and the supply pipeline sites. It is anticipated that these issues can be accommodated and/or mitigated where necessary.

There are a number of historically significant sites in the area of some of the proposed infrastructure; specifically the river intake, supply pipeline and storage reservoir. The implications of these impacts need to be assessed further.

The economic analysis completed for this study was divided into three parts: 1) a farm financial analysis; 2) a regional impact analysis, and 3) a provincial benefit-cost analysis. These analytical components are linked to one another so there is a logical and numerical consistency throughout.

The farm financial analysis employs budgets for a basket of crops for both irrigation and dryland and highlights the following:

- On-farm profitability is highly dependent upon the size of the farmers' contribution to irrigation system capital and operating costs. An annual operating cost contribution of about $50/acre is a likely maximum.
- Compared to dryland, irrigation would approximately quadruple production levels while capital requirements are estimated to climb about 5 times; labour requirements about 3 times. These requirements, in conjunction with other variables, would likely constrain irrigation development growth to about 3,000 acres per annum.
- Assuming an off-farm annual O&M system contribution of $50/acre, irrigated crop production should be much more profitable than existing dryland crop production. The gross margin/acre would be expected to climb 6.5 times; the rate of return to capital about 3 times; and family income/acre about 12 times.

The accompanying regional impact analysis indicates:

- Depending upon the extent of the irrigation development, the short-term and long-term stimulus to the local economy would be substantial. GDP, income, and employment would probably increase, say, 10 – 15 percent per annum in the first few years; probably about 5% per year in subsequent years.
- The estimated regional internal rate of return (where Benefits = Costs) for Scenarios 2 and 3 is about 3 percent per annum and the regional Benefit-Cost (B/C) ratio (at a discount rate of 4%) is approximately 0.95. From this perspective, therefore, Scenarios 2 and 3 (with a slight preference to Scenario 3) would both seem to be reasonably profitable investment opportunities.

When regional impacts are not considered a net benefit to the province, the provincial benefit-cost analysis tentatively concludes:

- For Scenarios 2 and 3, the internal rate of return is approximately 1.46% and 1.59% per annum and the B/C ratio (at a discount rate of 4%) is about 0.82.
- The corresponding sensitivity analysis indicates that for Scenario 3 (the economically "best" case), the confidence band which brackets the internal rate of return (IRR) of 1.59% could be as low as 1.0% and as high as 4.1% per annum. Similarly, the confidence band which brackets the B/C ratio of 0.82 (for a discount rate of 4%/annum) could be a low as 0.67 and as high as 1.01.

Scenarios 2 and 3 have the best B/C ratio, suggesting that the optimal irrigation development area is between 8,900 – 11,000 hectares (22,000 to 27,000 acres).

From a provincial benefit-cost perspective, irrigation development in the M.D. of Acadia could be a reasonably profitable investment opportunity for the Province. This is particularly true if prevailing regional socio-economic disadvantages are also considered in the final decision-making process. However; alternative sources of revenue and/or funding for both the initial capital outlay and the annual operating costs (river pumping) would be required to prove economic viability of irrigation development within the MD of Acadia.

Subsequent to securing revenue and/or funding sources for the project, additional engineering and site investigations would be required to confirm the technical viability and cost of the project. This would include detailed geotechnical and site analysis for the reservoir, dams and diversion works; further assessment of distribution layout requirements; determination of local buy-in and interest in the development; securement of the required water allocation and diversion rate from the Red Deer River; and further historical and environmental assessments.

1.0 INTRODUCTION

1.1 Background

At the request of the Municipal District of Acadia No. 34 (MD), a Project Committee was established to facilitate a study of "Irrigation Development" within the MD. The committee consisted of funding partners and representatives from the MD; Alberta Agriculture, Food and Rural Development (AAFRD); Alberta Environment (AENV); and Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada.

The Municipal District of Acadia No. 34 is one of the regions most severely impacted due to a lack of precipitation, secure water supply and economic growth and diversification. Agriculture is the predominant industry in the area. A change from dryland to irrigation farming could stabilize farm incomes, provide employment opportunities through the enhancement of new support industries and improve overall social conditions in the area. Earlier studies, carried out in the mid-1980's examined water supply alternatives for both municipal and irrigation purposes. However; the benefit/cost ratios were less than favourable and further investigations were not implemented.

Since the mid-1980's, development of the Valley South Water Co-op, and the implementation of privately operated irrigation systems on irrigable land near the Red Deer River within the MD, has significantly impacted project parameters for the potential irrigation projects studied in the 1980's. In addition, advances in irrigation infrastructure, conveyance efficiency and pressurized irrigation distribution systems have also been made.

As a result of these changes and the continuing challenges of an unsecured water supply to the area, the Project Committee assigned MPE Engineering Ltd. (MPE), in association with Ursus Ecosystem Management Ltd.; Madawaska Consulting Ltd.; Bison Historical Services Ltd.; Unitech Solutions Inc.; and Marv Anderson and Associates to undertake an up-to-date Conceptual Engineering Study, to examine the feasibility of developing a viable and sustainable irrigation project within the southern portion of the MD.

1.2 Scope

The scope of work for this study includes:

1) Review of previous reports and studies.
2) Determination of water availability from the Red Deer River for various irrigation scenarios.
3) Review and prioritization of irrigable land within the southern portion of the MD, as identified in previous studies.

4) Review and assessment of crop mix and water requirements suitable for irrigation development in the MD.

5) Develop three irrigation development scenarios to consider in detailed as part of the study.

6) Develop a Water Resources Management Model (WRMM) for the three specified development scenarios. Undertake system abstraction and numerical modelling to optimize the river diversion requirements, storage facilities, pump station, supply pipelines and distribution system configurations for the three scenarios.

7) Analyze various infrastructure options and complete a conceptual design for the recommended infrastructure for the three development scenarios.

8) Provide a review of physical environment, water quality and historical resources impacts that may be associated with the proposed development scenarios.

9) Develop capital, energy and operation and maintenance costs and undertake conceptual economic analysis; including a provincial, regional and farm-based benefit cost analysis.

2.0 PREVIOUS IRRIGATION STUDIES

2.1 Irrigation Feasibility Study on Acadia Valley Project 1985 - Alberta Agriculture, Project Planning Branch

This conceptual study was undertaken to determine the cost of supplying irrigation water to the vicinity of Acadia Valley. Four development levels were investigated, ranging in size from 809 to 8,094 hectares (2,000 to 20,000 acres). The proposed system diverted water out of the Red Deer River and delivered water through a pipeline to a main canal, interconnected to three storage reservoirs located along Kennedy Creek. The study did not include a distribution system and future water users were assumed to pump directly from the main conveyance system.

The capital cost for the four proposed development scenarios ranged from $ 3,397 to $8,772 per hectare ($1,375 to $3,550 per acre) in 1985 dollars. Annual pumping costs were estimated at approximately $148 per hectare ($60 per acre).

This conceptual report was considered to be a guide for future studies.

2.2 Acadia Valley (Block 24) and Acadia Valley South Land Irrigability Classification Report – Level III 1986 – Monenco Consultants Limited

A level III land irrigability classification study was undertaken on eleven townships of land south of Acadia Valley. The project area consisted of approximately 80,000 hectares (200,000 acres).

Based on extensive field and laboratory investigations, lands in the project area were found to be from Class 2 to Class 6, based on the Land Irrigability Classification system used in Alberta. Potentially irrigable land (Classes 2, 3 and 4) represented 75% of the project area, the majority of which was Class 2 and 3.

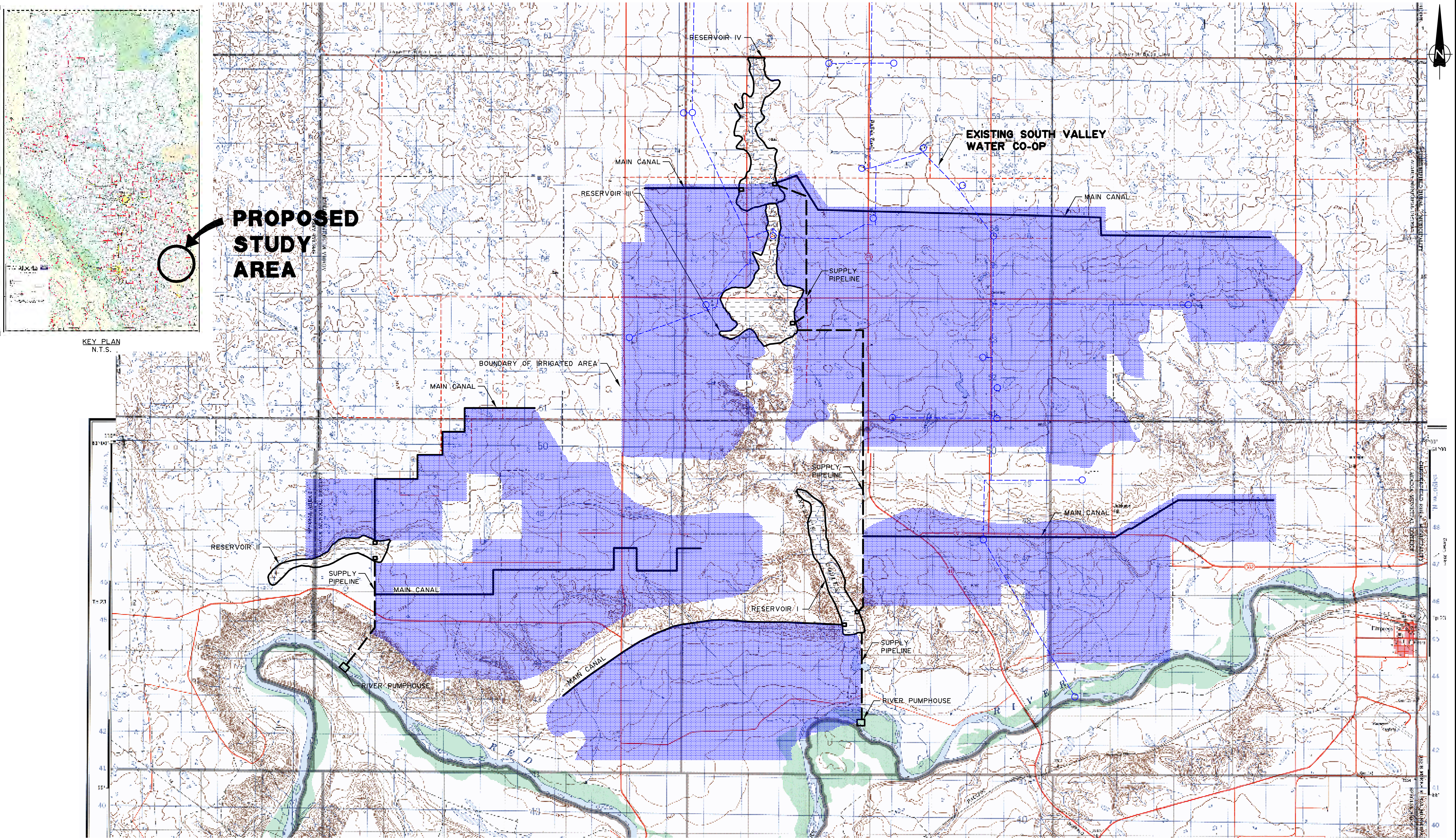
2.3 Water Supply to the Special Areas Phase 1 Study Report 1987 – Acres International Limited

In this conceptual study, potential irrigation developments of 4,050, 8,100 and 16,200 hectares (10,000; 20,000; and 40,000 acres) were investigated in the southern portion of the MD of Acadia. The system layout for the largest development scenario, (40,000 acres) is illustrated in Figure 2-1.

The crop mix that was proposed for the irrigation development consisted of approximately 67% alfalfa, 20% wheat and 13% barley. The proposed system diverted water directly from the Red Deer River and utilized up to three storage reservoirs for water balancing and temporary supply shortages. Water was re-pumped at each reservoir into main canals, which led to canal distribution systems for various irrigation blocks.

The diversion system was designed for rates varying from 3.4 m^3/s (122 cfs) to 13.8 m^3/s (488 cfs).

The unit costs for the proposed developments ranged from $8,450 to $9,860 per hectare ($3,420 to $3,990 per acre), in 1987 dollars. Annual system pumping costs were estimated at $91 per hectare ($37 per acre), not included on-farm pumping costs. The benefit-cost ratios associated with these alternatives ranged from 0.67 to 0.74.



□ – RIVER/RESERVOIR PUMPHOUSE

NOTE:
THIS FIGURE REPRODUCED FROM ACRES INTERNATIONAL REPORT ENTITLED "WATER SUPPLY TO THE SPECIAL AREAS, PHASE I STUDY REPORT", 1987

mpe ENGINEERING LTD. Calgary, Alberta	MD OF ACADIA NO. 34
	ACRES 1987 PHASE I STUDY POTENTIAL IRRIGATION DEVELOPMENT LAYOUT
SCALE: 1: 100,000	DATE: APRIL 2005
	FIGURE 2-1

3.0 SITE DESCRIPTION

3.1 General Area Description

The MD of Acadia is located in the south-eastern quadrant of Alberta, as shown on Figure 3-1. The MD is approximately 12 ½ townships in size, with a population of over 500 people. The Hamlet of Acadia Valley (with approximately 120 people), and the Acadia Hutterian Brethren Colony (with about 50 members), are the major population centres within the MD. Other major nearby centres include Oyen, Youngstown and Empress. The City of Medicine Hat is located approximately 157 km south of the Hamlet of Acadia Valley.

The MD is bordered by the Special Areas of Alberta on the north, south and west sides and the Province of Saskatchewan on the east side. The Red Deer River forms the southern border between the MD and Special Area No. 2. A primary highway, Hwy. #41, (also known as Buffalo Trail) runs north to south through the area.

The economy in the MD is primarily agricultural-based, with an emphasis on cereal crop and beef cattle production. There are also some oil and gas activity in the area and economic spin-offs services including supply of fuel, potable water, automotive services, restaurants, etc. The MD of Acadia was one of the few municipalities in the area which survived the depression of the 1930's; however, the area's population has decreased over the last several decades, largely as a result of rural residents moving to larger centres.

Numerous natural phenomenon and artifacts are located throughout the Municipality, many of which are located along the main drainage course traversing north to south through the area, Kennedy Coulee. A reservoir and recreation area (Acadia Recreational Reservoir), is located about 10 km. southwest of the Hamlet of Acadia Valley on Kennedy Coulee.

3.2 Study Area

The study area considered in this proposal is shown on Figure 3-2. This is the general area proposed for irrigation development in the studies completed in the 1980's, with the exception of about 15 quarter sections of land at the extreme northern end of the study area, that were added at the request of the MD.

3.3 Current Land Use

There are approximately 35,400 hectares (87,500 acres) of land within the study area. Approximately 20,800 hectares (51,300 acres) are under dryland cultivation and improved pasture/hayland, of which 490 hectares (1200 acres) are currently under irrigation. The remaining agricultural lands within the study area are native grasslands.

At the present time, livestock grazing is the land use in an estimated 40 % of the study area. The irrigated land is located primarily along the Red Deer River, due to its close proximity to a constant water supply.

Figure 3-3 provides an illustration of the existing land-use delineation for the study area. This image is produced from recent satellite imagery by selecting a composite of spectral bands 3, 5 and 4. This "supervised classification" produces the green area to delineate native grass cover, with the cultivated land/tame pasture in blue.

3.4 Existing Infrastructure

The rural study area is serviced by a number of infrastructure grids. These include grids for the supply of electricity (ATCO Electric), natural gas (Dry Country Gas Co-op Ltd) and water (Valley South Co-op Ltd). The general layout of these grids is shown on Figure 3-4.

The existing electrical grid is generally adequate for the supply of electricity for individual irrigation sites, but would not be adequate to supply power to any main lift stations that are required for the project.

The natural gas supply consists of a high-pressure transmission line running east-west through the north part of the study area, as well as various low-pressure distribution lines throughout the study area.

The water supply system for the Valley South Co-op Ltd was installed in 1999/2000. This system is supplied from a well in the floodplain of the Red Deer River located in N½ 7-Township 23 Range 1 W4. This water distribution system is designed for domestic (livestock) and other agricultural purposes, but does not have the capacity to service any large scale irrigation development.

3.5 Topography / Drainage

The lands included in the study area are generally sloping southeast towards the river. The area is drained by Kennedy Coulee which splits the study area in two parts. There are a few additional east-west tributaries that drain smaller areas into Kennedy Coulee. Kennedy Coulee discharges into the Red Deer River, just upstream of the Highway #41 bridge. Refer to Section 5 and "Appendix D for a discussion on surface hydrology.

3.6 Bedrock and Surficial Geology

A brief review of existing bedrock formation and surficial geology mapping was completed for the study area. The available mapping is accessible via the internet webpage for the Alberta Geological Survey. The mapping shows that there are two main bedrock formations underlying the study area:

1. the Oldman Formation
2. the Bearspaw Formation

These formations are Upper Cretaceous strata. The southern strip of the study area (adjacent to the Red Deer River valley) is situated over the Oldman Formation, whereas the northern two-thirds of the study area is underlain by the Bearspaw Formation.

The bedrock mapping (NTS Map Sheet Medicine Hat 72L, prepared in 1970 by the Research Council of Alberta) shows that the bedrock elevation is approximately 600 m above sea level directly north of the Red Deer River, and generally rising in a northwesterly direction. Mapping (either in paper or digital format) for the adjacent Map Sheet (Oyen 72M) is not available, but the study review included projection of the data from the data in Map Sheet 72L.

The surficial deposits are sufficiently thick to allow for the development of the irrigation system, and depth to bedrock is generally not considered to be a limiting factor.

The main surficial deposits are described as follows:

Southern 75% of Block 1A; Irrigation Block 1B; Block 2 and most of Block 3:
Map Legend "Code 2b": Lacustrine deposit, fine sediment silt and clay on a flat to gently undulating surface.

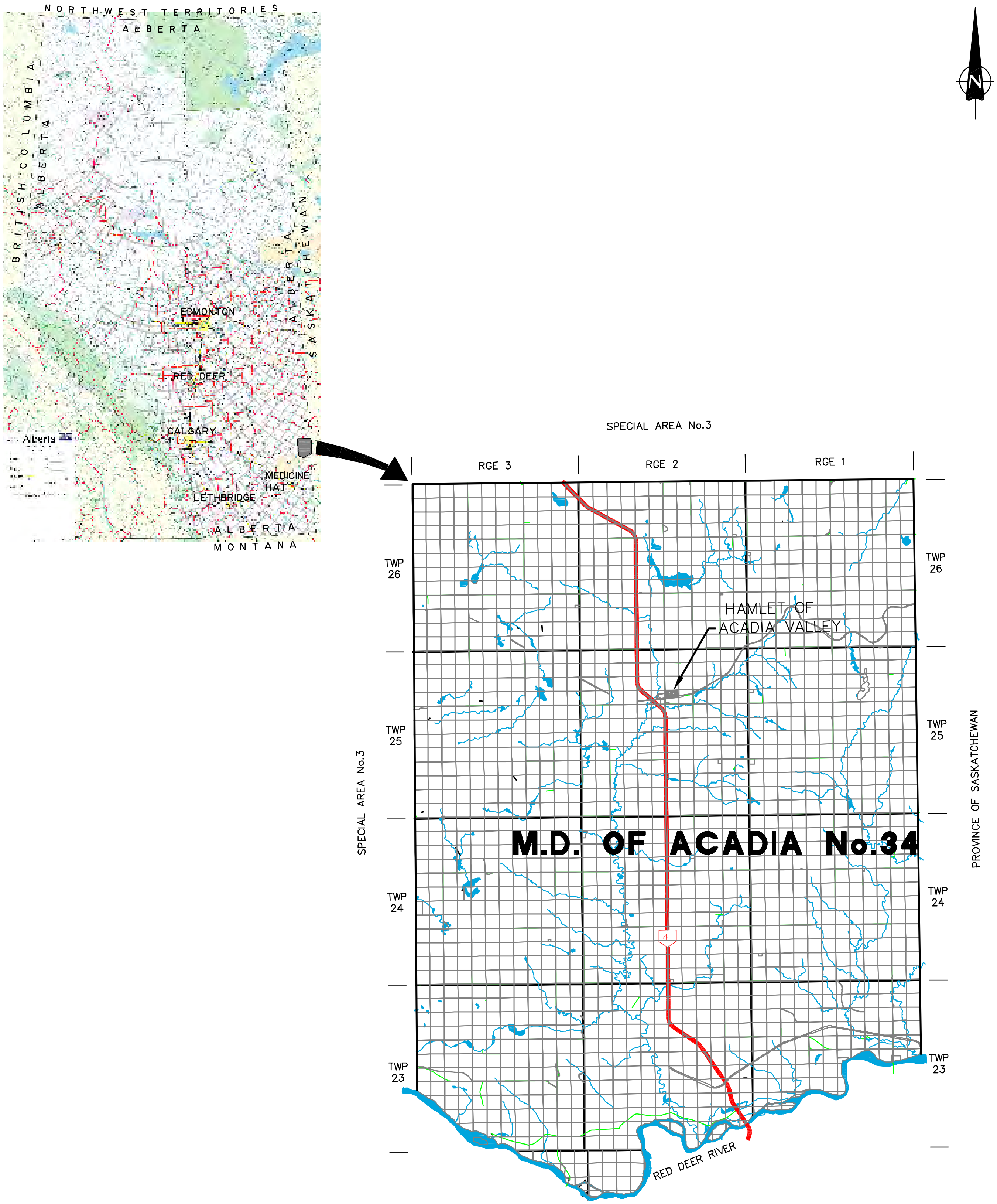
Irrigation Block 3 (east end):
"Map Legend Code 10b": Glacial deposit, till consisting of unsorted mixture of clay, silt, sand and gravel, hummocky topography with irregularly shaped and poorly defined knobs and kettles.

Irrigation Block 1 (north part) and Block 4 :
"Map Legend Code 9": Glacial deposit, till of even thickness, local bedrock exposure and flat undulating surface reflecting the topography of the underlying bedrock and other deposits.

For purposes of the study, it is assumed that all open channel irrigation distribution will be lined canals, to prevent seepage. Certain parcels within the study area (i.e. those with lacustrine silt and clay deposits) may not need to be lined, however the current emphasis on water conservation combined with the high cost of pumped water supply dictates that lined canals are preferred.

The proposed Reservoir A1 is located in the south west part of the study area in a tributary valley to Kennedy Coulee. Mapping shows this area to consist of ice-contacted lacustrine, thin deposits of silt and clay with minor sand and gravel in the valley and thin colluvial cover on the valley slopes. The bedrock mapping shows the local bedrock elevation to be approximately 685 m (2250') above sea level, whereas the study terrain model shows the valley bottom elevation varying from 700 m – 710 m (therefore bedrock appears to be 15 - 25m below surface in this area).

Figure 3-5 illustrates the surface geology features within the general study area for this project.



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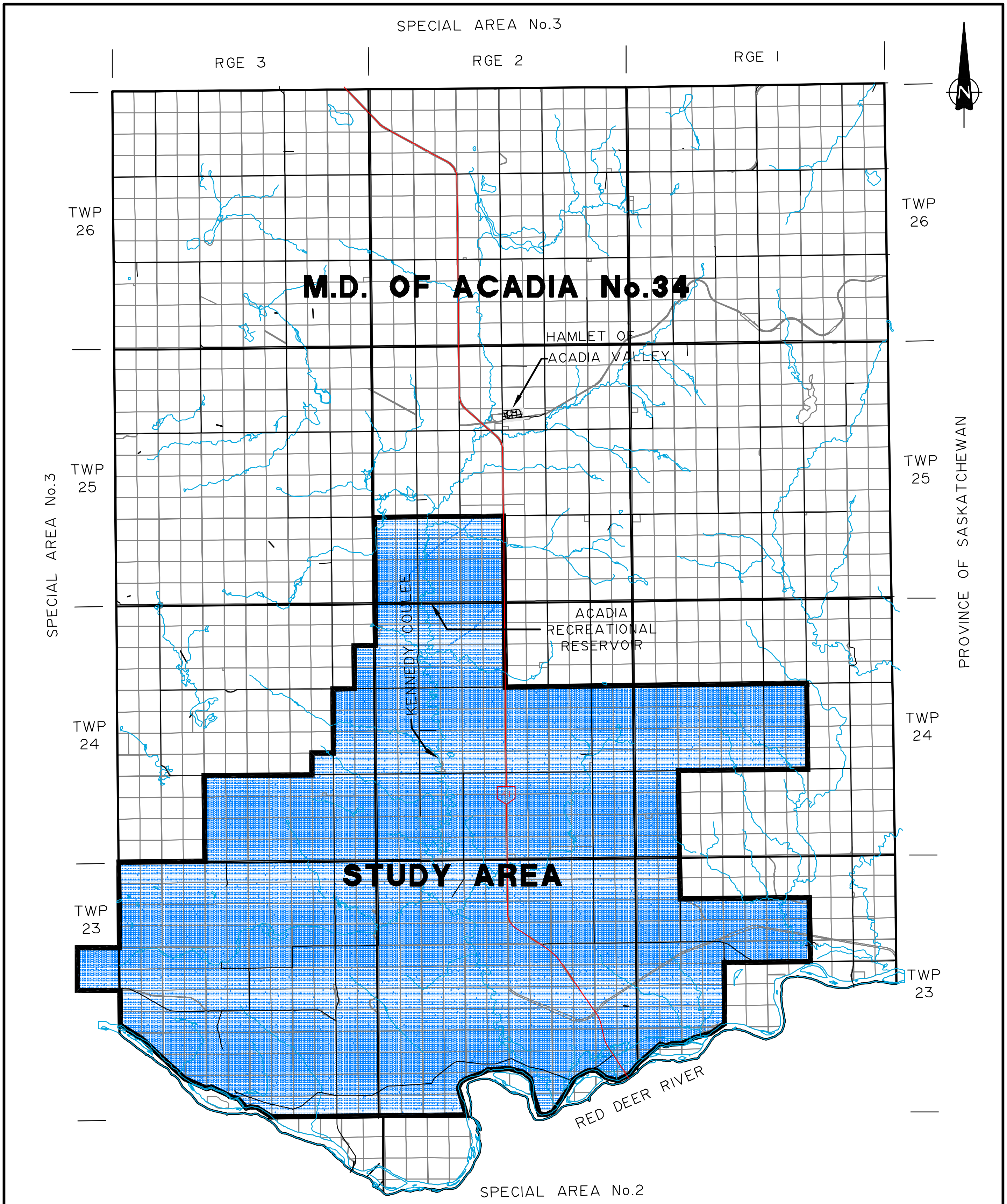
M.D. OF ACADIA No.34

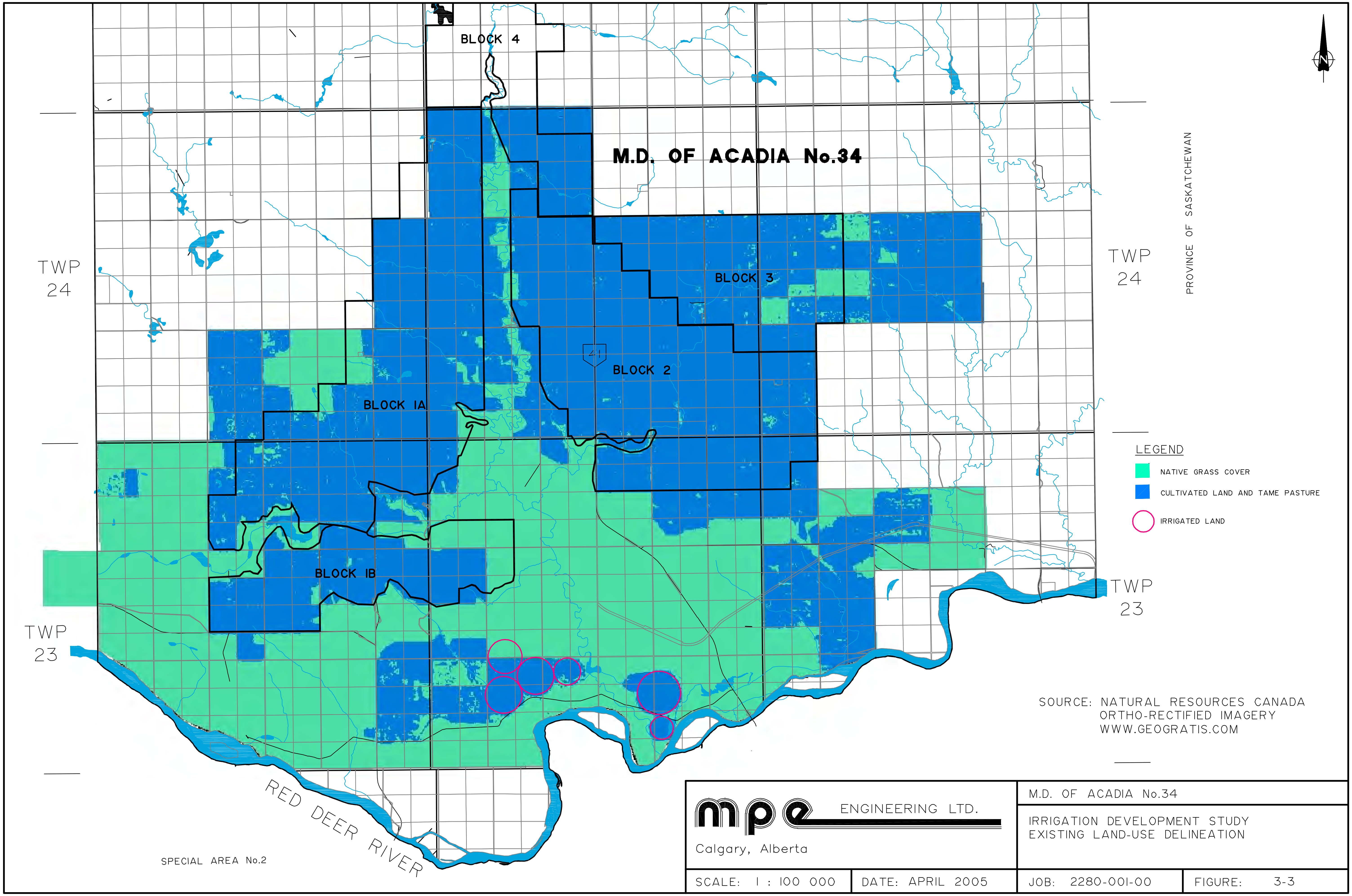
IRRIGATION DEVELOPMENT STUDY
LOCATION PLAN

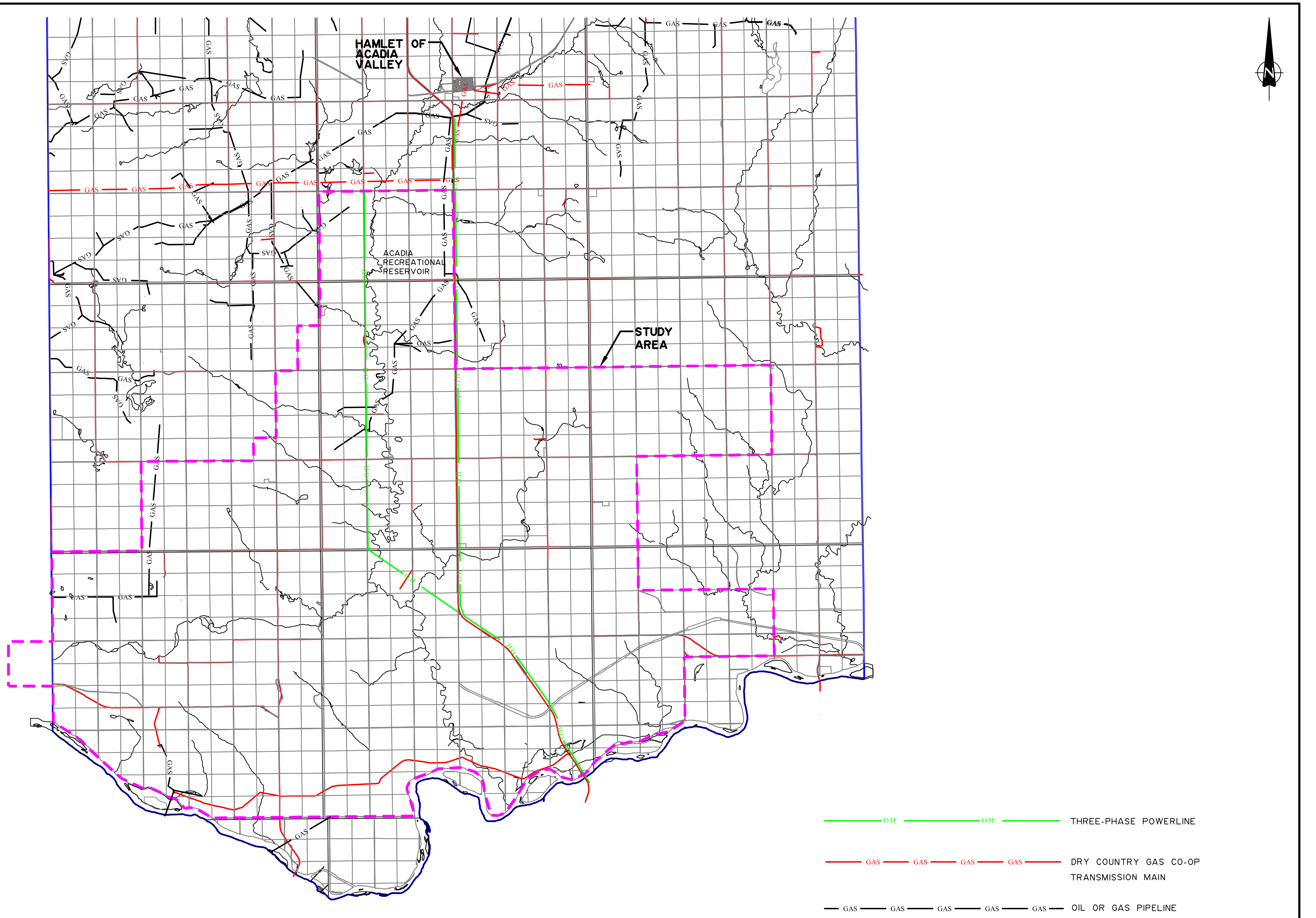
SCALE: N.T.S.	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 3-1



mpe ENGINEERING LTD. Calgary, Alberta	M.D. OF ACADIA No.34 IRRIGATION DEVELOPMENT STUDY STUDY AREA

SCALE: 1: 200,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 3-2


M.D. OF ACADIA No.34
BLOCK 4
BLOCK 3
BLOCK 2
BLOCK IA
BLOCK IB
41
TWP 24
TWP 23
TWP 24
TWP 23
PROVINCE OF SASKATCHEWAN
LEGEND
NATIVE GRASS COVER
CULTIVATED LAND AND TAME PASTURE
IRRIGATED LAND
SOURCE: NATURAL RESOURCES CANADA
ORTHO-RECTIFIED IMAGERY
WWW.GEOGRATIS.COM
RED DEER RIVER
SPECIAL AREA No.2
mpe ENGINEERING LTD.
Calgary, Alberta
M.D. OF ACADIA No.34
IRRIGATION DEVELOPMENT STUDY
EXISTING LAND-USE DELINEATION
SCALE: 1 : 100 000
DATE: APRIL 2005
JOB: 2280-001-00
FIGURE: 3-3



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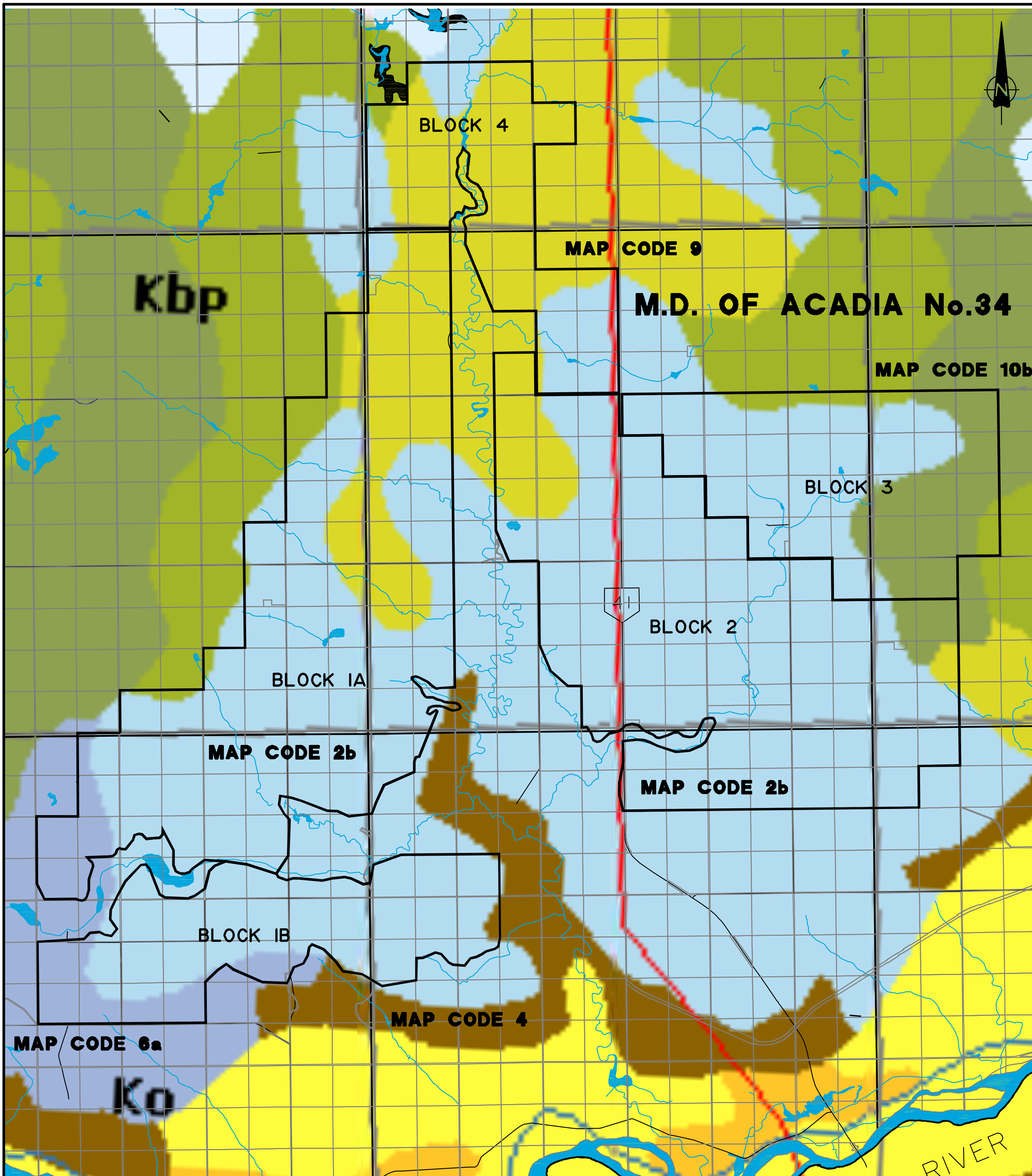
Calgary, Alberta

M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY
EXISTING UTILITY INFRASTRUCTURE

SCALE: 1 : 150,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 3-4



MAP LEGEND CODES:
2b: LACUSTRINE, SILT AND CLAY
4: ERODED STREAM/SLOPEWASH
6a: ICE-CONTACTED LACUSTRINE
9: GLACIAL TILL
10b: GLACIAL TILL, HUMMOCKY TERRAIN
(FURTHER DETAILED IN REPORT)

Kbp: BEARSPAW FORMATION
Ko: OLDMAN FORMATION

SOURCE: ALBERTA GEOLOGICAL SURVEY

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M.D. OF ACADIA No.34

IRRIGATION DEVELOPMENT STUDY
SURFICIAL GEOLOGY

SCALE: 1 : 100,000	DATE: APRIL 2005	JOB: 2280-001-00	DRAWING: 3-5

4.0 IRRIGATION DEVELOPMENT

4.1 Irrigable Land Assessment

Level III Land Classification mapping was completed for an eleven township block of land in the MD of Acadia in 1986 (Monenco). This mapping was completed for AAFRD and was based on the Land Irrigability Classification System used in Alberta. The mapping included the majority of the current study area, with the exception of lands in Township 23, 24 & 25, Range 1, W4. The land classification maps were digitized by AAFRD in the fall of 2004 for the purposes of this study. The digitized land classification, relative to the study area boundary, is illustrated on Figure 4-1.

The lands within the project area vary from Class 2 to Class 6, with the vast majority being Class 2 and 3 lands. Under the Land Irrigability Classification System used in Alberta, potential irrigable land falls under Classes 2, 3 and 4, while Class 5 and 6 lands are not considered irrigable. The Class 5 & 6 lands within the study area are primarily concentrated within the coulees (i.e Kennedy Coulee and its tributaries; and the Red Deer River Valley slopes). Class 4 lands are generally considered marginal for irrigation because they have restricted capability requiring special system design and/or special management (i.e limitations due to salinity, soil restraints, and/or topography limitations). There is very little Class 4 land within the study area; therefore, for the purposes of determining irrigation development for this report, only Class 2 and Class 3 lands were considered.

4.2 Irrigation Blocks

The determination of the irrigation blocks for this study was made in collaboration with the project committee and took into account a number of considerations and factors, including the following:

1) The use of Crown Land for irrigation was minimized.
2) Only Class 2 and 3 Lands were considered for irrigation.
3) Lands that are located in close proximity to the Red Deer River were not included in this study. This is primarily because they could likely be serviced directly from the river more economically than a central conveyance system (any central system for this area would incorporate high-lift pumping to a storage reservoir and conveyance canals would have to traverse coulees and creeks which would intersect canal or pipeline alignments). The lands located within the Red Deer River Valley could also pose significant environmental, paleontological and historical resource concerns.
4) Lands located in the eastern half of Range 1 were not considered in the irrigation development blocks. This was in part due to higher infrastructure costs to deliver water to these areas from the proposed water storage reservoirs; and also due to high salinity and topographical challenges in the area. It should be noted that the concerns about salinity problems in this area are based on an overview of 2003

aerial photography as well as personal observations from local project committee members. These salinity problems are not identified in the 1998 Salinity Mapping program prepared by the Conservation and Development Branch of AAFRD.

5) Irrigation blocks were laid out to maximize the gravity conveyance and distribution systems and minimize the need for re-pumping out of the storage reservoirs.

6) The developable area within the defined irrigation blocks were based on the following criteria:

   - Land parcels on the high side of canals were limited to a distance of 1.6 km from the canal and an elevation gain of ≤ = 20 m.
   - Developable area for a standard ¼ section pivot was based on 53.8 ha (133 acres) being irrigated.
   - Land parcels smaller than 32 hectares (80 Acres) in size were not considered in the irrigated area calculations for each block.
   - Maximum terrain slope for pivot development was set at 15%.
   - The portion of irrigable parcels that contained existing farms, homesteads, roads, drainage courses and other significant infrastructure was excluded.

7) A small irrigation block with a pressurized pump system was included around the MD of Acadia Recreational Reservoir. Land parcels to be irrigated within this block to be within 3 km of the reservoir and have a maximum static lift requirement of 20 m.

8) Potentially irrigable land that would require direct pumping out of the proposed storage reservoir was not considered in the irrigated land area calculations for this study. (This could add approximately 300 hectares (790 acres) to all of the development scenarios, however the majority of this land is on Crown Land and each landowner would require a pump site at the reservoir with significant static lift capability). Also the parcels north of the reservoir involve land that is classified as Class 4, considered marginal for irrigation development.

The irrigation blocks identified for this study are shown on Figure 4-2. The location of Crown land within the study area is also identified on this figure. A summary of the irrigated area assigned to each block is presented in Table 4.1. It should be noted that the total amount of area on crown land for all five irrigation blocks is 325 ha (800 acres).

Table 4.1
Irrigation Block Irrigable Areas

Irrigation Block	Irrigated Area	
	(Hectares)	(Acres)
Block 1A	3,157	7,800
Block 1B	1,295	3,200
Block 2	3,440	8,500
Block 3	2,023	5,000
Block 4	1,012	2,500
Total	***10,927***	***27,000***

Note: The assigned irrigated areas for each block in Table 4.1 do not relate to the gross area within the block boundary delineation, but instead are a conceptual level estimate of the irrigable land that can be serviced within the block, based on the criteria established above.

4.3 SSRB Regulation

The South Saskatchewan River Basin (SSRB) Regulation specifies a maximum acreage cap for irrigation development within the Red Deer River Basin of 39,254 ha (97,000 acres). A review of the amount of irrigation development still available within the basin (based on the Regulation Cap) was completed by AENV for this study. This review considered all existing licenses and preliminary certificates and all current applications, and determined that approximately 7,862 ha (19,428 acres) were available for future applications as of October, 2004.

Table 4.2 provides a summary of review of existing and/or committed irrigation development within the Red Deer River Basin:

Table 4.2
Red Deer River Basin
Existing & Committed Irrigation Development

Description	**Irrigation Development Area**	
	Hectares	**Acres**
Existing & Committed Irrigation Development		
Current Licenses / Certificates	12,961	32,026
Groundwater Irrigation	32	80
Private Applications	189	466
Deadfish/Sheerness Project	8,094	20,000
SAWSP Application	10,117	25,000
Total Committed	**31,392**	**77,572**
SSRB Regulation Cap	**39,254**	**97,000**
Total Available Under Current Regulation	**7862**	**19,428**

It should be noted that Table 4.2 assumes 25,000 acres of development for SAWSP. The most current studies and WRM modelling for SAWSP is considering 20,000 acres. Therefore, under the Regulation, the maximum available irrigation development for the MD of Acadia project is approximately 20,000 to 25,000 acres; or 8,100 to 10,100 hectares.

4.4 Development Scenarios

4.4.1 Initial Optimization Process

An "optimization" process was completed in the initial stages of the study, which included reviewing a number of development scenarios and infrastructure options in conjunction with WRM modelling. This process was completed in order to balance the competing objectives of optimizing water availability; maximizing irrigation development; and minimizing river diversion and reservoir infrastructure and operation costs (particularly energy costs). Previous concepts (ACRES 1987) utilized numerous reservoirs, incorporated double pumping (water is pumped from the River to a Reservoir and then re-pumped to the various irrigation blocks) and sized the diversion system from the River on the actual irrigation demand.

Refer to the Committee meeting minutes and information packages in Appendix C for additional information on the initial development scenarios that were considered. A summary of the basic findings and conclusions of the "optimization" process is summarized as follows:

1) A comparison of diversion rates versus reservoir storage requirements (taking into account water availability in the River) determined that the optimum river diversion rates were:

River Diversion Rate (m3/s)	Irrigation Development
2.0 m^3/s	4,000 – 6,000 ha. (10,000 – 15,000 ac.)
3.0 m^3/s	6,000 – 9,000 ha. (15,000 – 20,000 ac.)
4.0 m^3/s	9,000 – 12,000 ha. (20,000 – 30,000 ac.)

2) It was determined that the most economic off-stream storage alternative was a single reservoir (Reservoir A1) located on a tributary to Kennedy Coulee, just north of the River and near the west boundary of the MD. Reservoir sites on Kennedy Coulee (downstream of the Acadia Recreational Reservoir) were investigated; however the steepness of the Coulee and the significant environmental and historical impacts that would be associated with development along Kennedy Coulee limited the cost-effectiveness of these sites. In addition, any reservoirs located in Kennedy Coulee would require re-pumping to deliver water to the irrigation blocks, whereas some gravity delivery was possible from Reservoir A1.

3) It was determined that water could be gravity delivered to Blocks 1A, 1B and 2 from Reservoir A1. Irrigation water for Blocks 3 and 4 could also be gravity delivered to the Acadia Recreational Reservoir, from where a pressurized system is required to deliver water to the land parcels.

4) It was determined that it was more economical to build the Reservoir A1 dam higher and have unused (dead) storage left in the reservoir, than to build a lower dam and pump the dead storage into the delivery canal.

4.4.2 Development Scenarios

Three development scenarios were selected for this conceptual study, in order to provide a range of low, medium and large irrigation development alternatives for the MD. At the MD's request, Block 4 was included in all of the development scenarios.

The three development scenarios selected for this study are summarized in Table 4.3.

Table 4.3
Irrigation Development Scenarios

Development Scenario	Irrigation Blocks	Total Irrigated Area	
		(Hectares)	(Acres)
Scenario 1	Blocks - 1A, 1B & 4	5,500	13,600
Scenario 2	Blocks - 1A, 1B, 2 & 4	8,904	22,000
Scenario 3	Blocks - 1A, 1B, 2, 3 & 4	10,927	27,000

Scenario 3 is slightly over the current available area under the SSRB Regulation irrigation cap, but is close enough to consider further as the large (or upper end) development alternative for this study.

The selected development scenarios are illustrated on Figures 4-3, 4-4 and 4-5. Modelling simulation results for the scenarios are discussed in Section 6, while a detailed review and discussion of the infrastructure components is provided in Section 7.

4.5 Crop Mix and Water Requirements

4.5.1 Crop Mix and IDM Modelling Parameters

AAFRD completed an Irrigation Demand Model (IDM) for the MD of Acadia area (Acadia Block 328) in 2003 as part of the South Saskatchewan River Basin WRMM completed by AENV. AAFRD updated the IDM as part of this study to reflect the infrastructure layout as discussed in Section 4. The on-farm irrigation equipment mix was also modified to reflect technology advancements and a realistic expectation of the type of irrigation equipment that would be used in this area.

The following parameters and assumptions were used by AAFRD in the updated IDM completed for this study:

1) The system layout for Development Scenario 2 was used to represent the crop demand requirements for all three development scenarios.
2) The IDM was done for the historic period from 1928 to 1995 (68 years).
3) Irrigated soils were assumed to be of medium texture and canal segments clay-lined, resulting in a minimum seepage factor.
4) The model assumes that every field is cropped and will be irrigated if called for by local field soil moisture conditions. This is a 'conservative' water demand factor.
5) Crop water demand was based on AAFRD's intensive climate data which is based on virtual climate stations located at the centre of each township.

6) Irrigation management levels were assumed to be “Good” (meaning that farmers apply 80% of the required irrigation water for optimum crop production). The on-farm system management factor was established as “Standard” (meaning that there could be some slight room for efficiency improvements in the future). This again is a ‘conservative’ water demand factor.

7) The irrigation equipment mix used for the IDM is as follows:

Equipment Type	Percent Used
Hand-Move	5 %
High-Pressure Pivots	35 %
Low-Pressure Pivots	50 %
Wheel-Move	10 %

The crop mix used in the IDM is illustrated in Table 4.5. This mix assumes that 67.9 % of the irrigated crop will be forage. It is possible that this amount of forage may decrease somewhat over time with a higher percentage of specialty and cereal crops be incorporated. However; the Committee felt that the mix was realistic considering that the current agricultural base of the area is livestock-driven and value-added markets are a considerable distance from the area.

8) In addition to run-off spills, a constant base flow in the canal system is normally incorporated in AAFRD’s IDM. For this project it was set at 0.05 m^3/s.

Table 4.4
Crop Type Mix

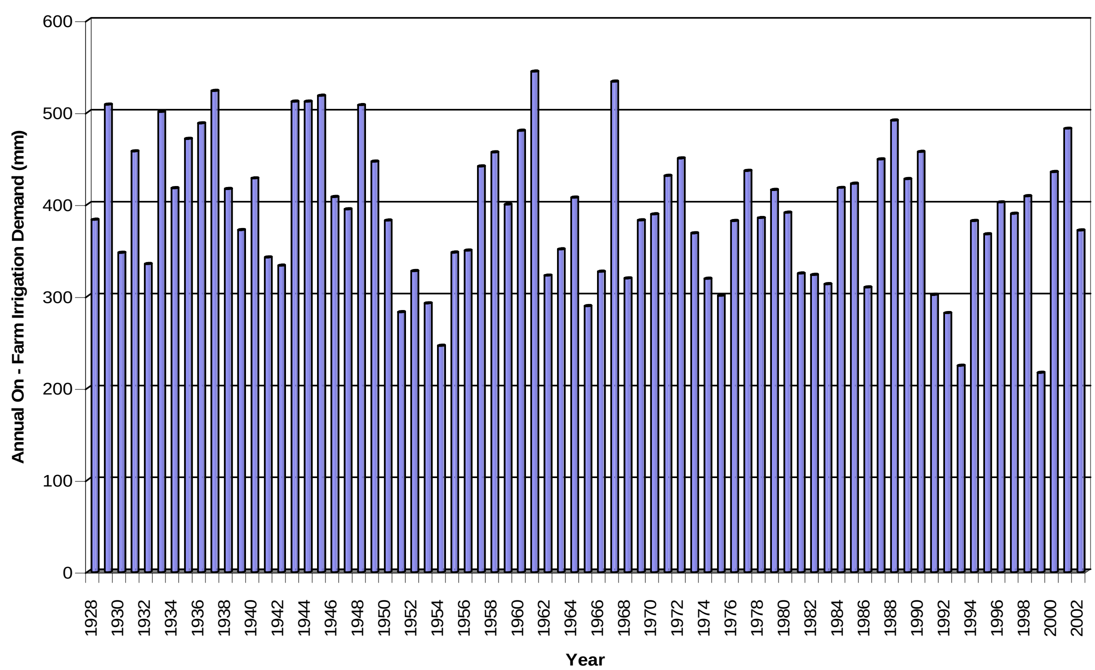
Crop Group	Crop Name	Crop Area (% of Total)
Cereal	Barley	19.4 %
	Wheat	8.8 %
	Cereal Sub-total	*28.2 %*
Forage	Alfalfa (2 cut)	45.8 %
	Alfalfa Hay	8.4 %
	Barley Silage	3.8 %
	Grass Hay	8.7 %
	Tame Pasture	1.2 %
	Forage Sub-total	*67.9 %*
Oilseed	Canola	3.8 %
	Oilseed Sub-total	*3.8 %*
Total		**100 %**

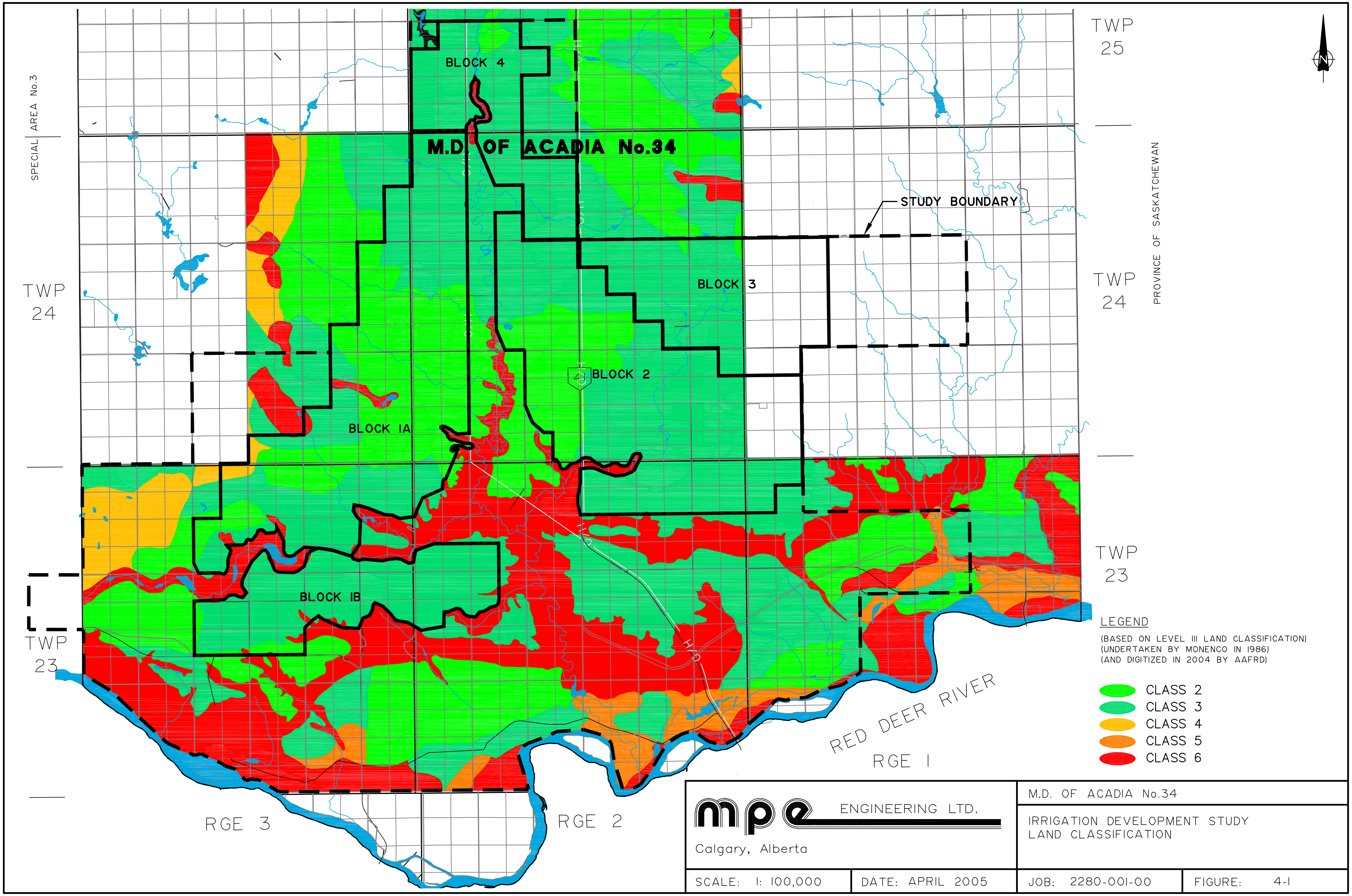
4.5.2 Water Requirements

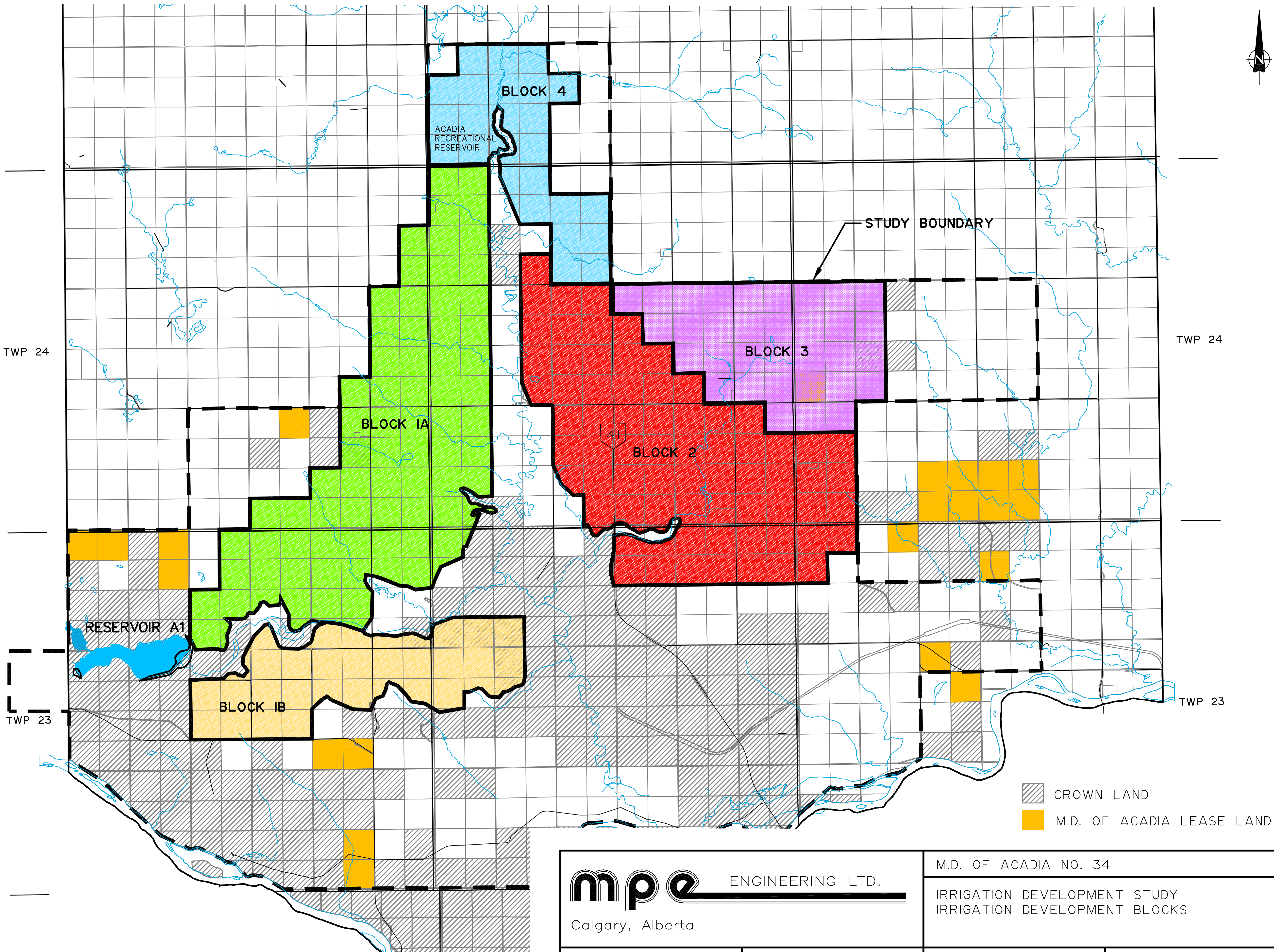
The IDM determined that the overall Gross Diversion Demand (GDD) – (without reservoir losses), was 414 mm/ha (16.3 inches of water per irrigated acre). The GDD includes approximately 3% of the diverted water lost due to seepage and evaporation in the distribution system and an additional 5% being unused within the project and returned to the river (i.e return flows). Losses due to reservoir evaporation and seepage are addressed separately in the WRMM and not included in the GDD. The GDD for the modelling period is shown on Chart 4A.

The on-farm demand and return flow files produced by the IDM were implemented into the WRMM undertaken on the three development scenarios. In addition to these water requirements, reservoir losses due to evaporation and seepage were also built into the WRMM. This information is discussed in Section 6.0.

Chart 4A
Irrigation Demand For M.D. of Acadia Valley
(Excluding Reservoir Losses)




M.D. OF ACADIA No.34
BLOCK 4
BLOCK 3
BLOCK 2
BLOCK IA
BLOCK IB
STUDY BOUNDARY
SPECIAL AREA No.3
PROVINCE OF SASKATCHEWAN
TWP 25
TWP 24
TWP 24
TWP 23
TWP 23
RGE 3
RGE 2
RGE 1
RED DEER RIVER
LEGEND
(BASED ON LEVEL III LAND CLASSIFICATION)
(UNDERTAKEN BY MONENCO IN 1986)
(AND DIGITIZED IN 2004 BY AAFRD)
CLASS 2
CLASS 3
CLASS 4
CLASS 5
CLASS 6
mpe ENGINEERING LTD.
Calgary, Alberta
M.D. OF ACADIA No.34
IRRIGATION DEVELOPMENT STUDY
LAND CLASSIFICATION
SCALE: 1: 100,000
DATE: APRIL 2005
JOB: 2280-001-00
FIGURE: 4-1



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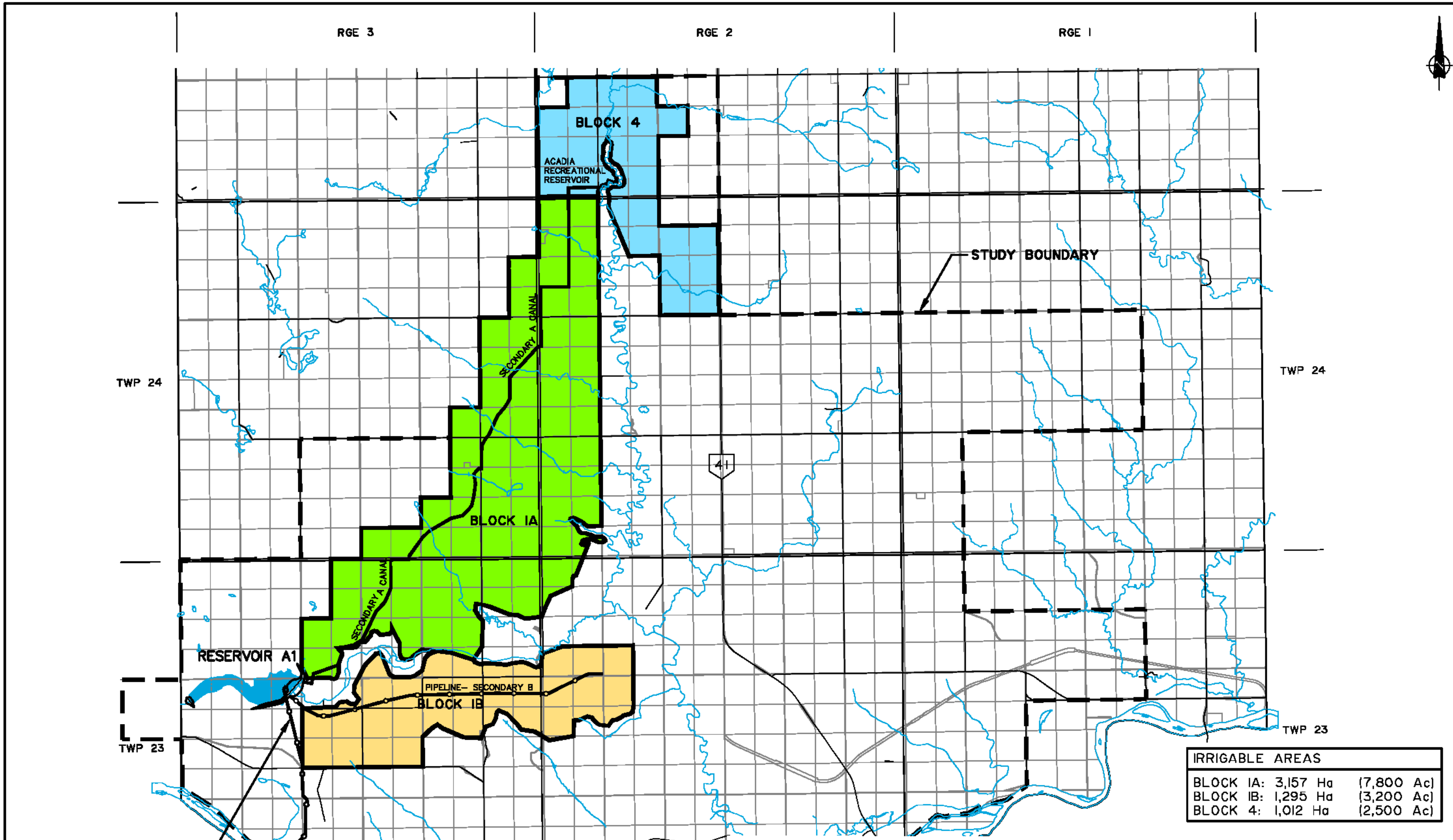
Calgary, Alberta

M.D. OF ACADIA NO. 34

IRRIGATION DEVELOPMENT STUDY
IRRIGATION DEVELOPMENT BLOCKS

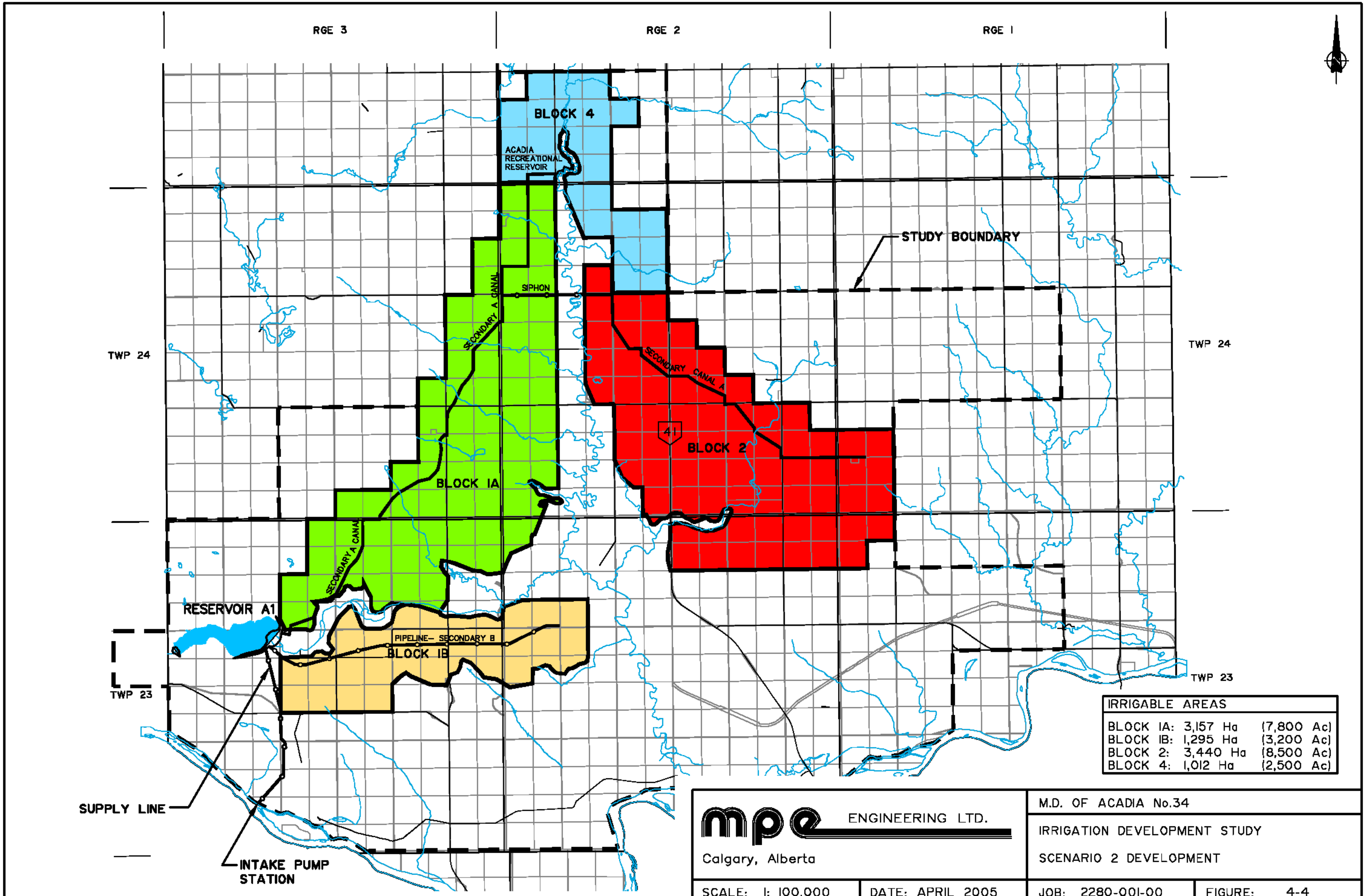
SCALE: 1: 100,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 4-2



mpe ENGINEERING LTD.
Calgary, Alberta

M.D. OF ACADIA No.34
IRRIGATION DEVELOPMENT STUDY
SCENARIO I DEVELOPMENT

SCALE: 1: 100,000 | DATE: APRIL 2005 | JOB: 2280-001-00 | FIGURE: 4-3


RGE 3
RGE 2
RGE 1
TWP 24
TWP 24
TWP 23
TWP 23
BLOCK 4
ACADIA RECREATIONAL RESERVOIR
STUDY BOUNDARY
SIPHON
SECONDARY A CANAL
SECONDARY CANAL A
41
BLOCK 2
BLOCK IA
RESERVOIR A1
PIPELINE– SECONDARY B
BLOCK IB
SUPPLY LINE
INTAKE PUMP STATION
IRRIGABLE AREAS
BLOCK IA: 3,157 Ha (7,800 Ac)
BLOCK IB: 1,295 Ha (3,200 Ac)
BLOCK 2: 3,440 Ha (8,500 Ac)
BLOCK 4: 1,012 Ha (2,500 Ac)
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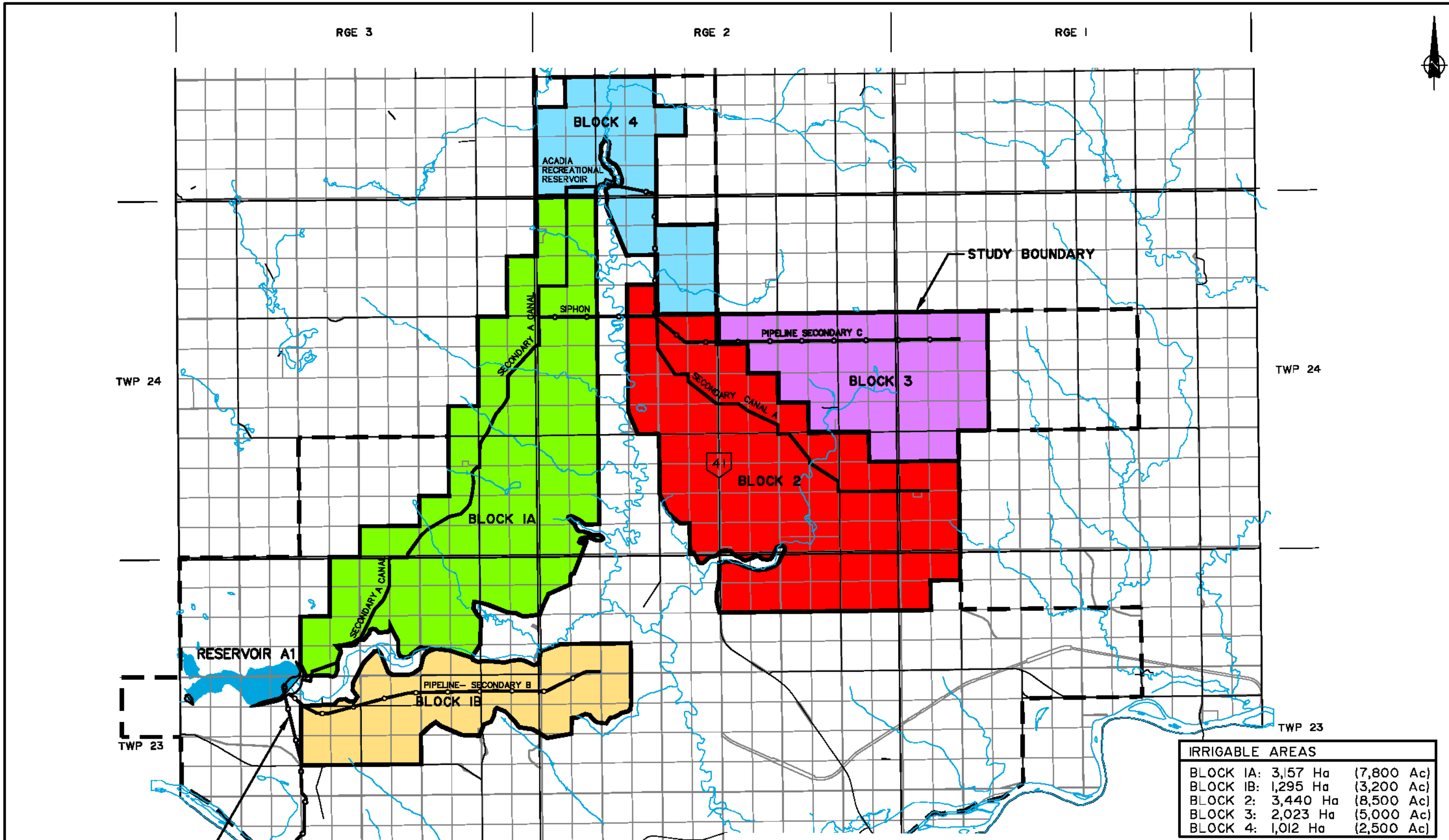
M.D. OF ACADIA No.34
IRRIGATION DEVELOPMENT STUDY
SCENARIO 2 DEVELOPMENT
SCALE: 1: 100,000
DATE: APRIL 2005
JOB: 2280-001-00
FIGURE: 4-4



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M.D. OF ACADIA No.34

IRRIGATION DEVELOPMENT STUDY

SCENARIO 3 DEVELOPMENT

SCALE: 1: 100,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 4-5

5.0 SURFACE HYDROLOGY

5.1 General

The MD of Acadia is a relatively dry area of the province that experiences significant dry periods (minimal or no runoff). In discussions with MD staff, runoff can be considerable when it occurs (usually spring snowmelt) but several years can pass without any measurable runoff at all. This is supported by the historic records of the only Water Survey Canada (WSC) station in the MD (Kennedy Coulee near the Hamlet of Acadia Valley - #05CK006), as shown on Table 5.1. This station is located on Kennedy Coulee, immediately below the Acadia Recreational Reservoir. The station's gross drainage area (GDA) is 939 km^2, while the effective drainage area (EDA) is 235 km^2. Annual historical runoff volumes for Kennedy Coulee are negligible, (less than 500 dam^3) 80% of the time. Zero run-off years occurred for five consecutive years in a row between 1998 and 2002. High runoff events do occur occasionally however, with the highest recorded maximum instantaneous flow on record being 47.3 m^3/s in 1997, with a total runoff volume that spring of 8,570 dam^3.

Table 5.1
Kennedy Coulee Near Hamlet of Acadia Valley (WSC 05CK006)

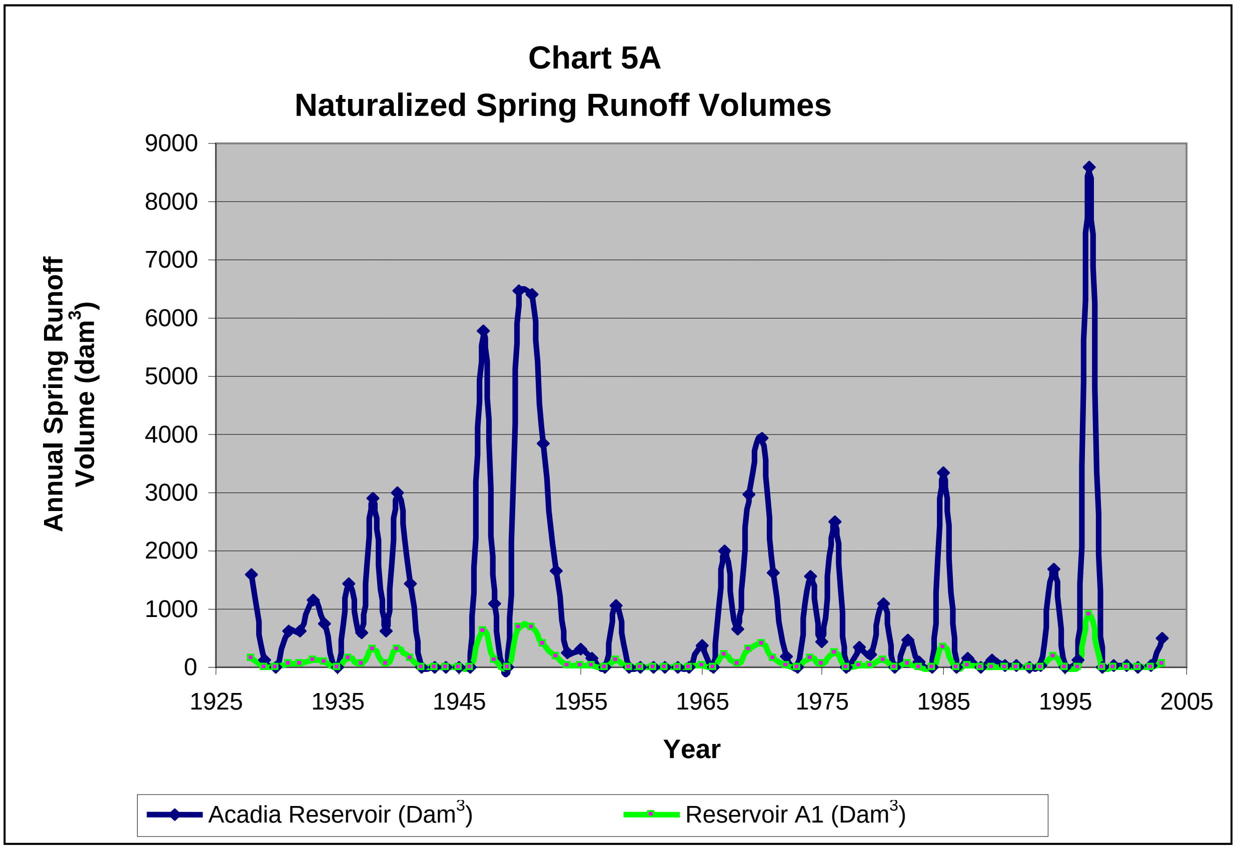
Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Annual Discharge (dam^3)
1982	----	0.728 on Mar 29	0.000B on Mar 01	440
1983	----	0.179B on Mar 14	0.000B on Mar 01	59.8
1984	----	0.000B on Feb 28	0.000B on Feb 28	0.000
1985	----	9.60B on Apr 02	0.000B on Mar 01	3.320
1986	----	0.004 on Feb 26	0.000B on Feb 18	0.346
1987	----	0.306 on Mar 26	0.000B on Feb 18	132
1988	7.00A at 11:00 MST on Jun 09	5.57 on Jun 09	0.000 on Feb 17	851
1989	----	0.556 on Apr 03	0.000 on Mar 01	107
1990	----	0.000 on Feb 26	0.000 on Feb 26	0.000
1991	----	0.000A on Feb 19	0.000A on Feb 19	0.000
1992	----	0.000B on Feb 24	0.000B on Feb 24	0.000
1993	----	0.800 on Jul 28	0.000B on Feb 24	109
1994	----	5.99B on Mar 17	0.000B on Mar 01	1 660
1995	----	0.000 on Feb 22	0.000 on Feb 22	0.000
1996	----	0.415B on Mar 19	0.000B on Feb 27	93.7
1997	47.3 on Mar 26	33.5 on Mar 27	0.000B on Feb 24	8 570
1998	----	0.000 on Feb 25	0.000 on Feb 25	0.000
1999	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000
2000	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000
2001	----	0.000 on Mar 01	0.000 on Mar 01	0.000
2002	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000

5.2 Natural Flows

Surface hydrology in this area is sporadic at best; therefore, runoff cannot be relied on to meet irrigation demand requirements and therefore has little or no impact on the River diversion or reservoir storage requirements for the three development scenarios. For the purposes of this study however; natural spring runoff flows at the Acadia Recreational Reservoir and Reservoir A1 were determined and incorporated into the WRMM model for the determination of the annual irrigation water balance and diversion requirements from the Red Deer River for each development scenario.

Flow records from the Kennedy Coulee WSC station (Kennedy) indicate that 94% of the runoff recorded between 1982 and 2003 occurred in March and April, and thus represent spring runoff (snow melt). Only twice over the 22 year record did summer rainfall result in any measurable runoff. This indicates that summer precipitation events would have negligible impact on water balance modelling for the development scenarios. Therefore, only the naturalized volumes resulting from spring runoff were developed for this study. Natural flows for the WRMM modelling were derived for the period from 1928 to 1995, by converting the naturalized volumes to flows, over a three week period in the spring (Mid-March to early-April).

A summary of the natural spring runoff volumes (annual) is provided in Chart 5A. A detailed review of the methodology used for development of the natural flows and the resulting weekly natural flow files used for the WRMM modelling is provided in Appendix D.



5.3 Peak Flow Estimates

Peak flow estimates and hydrographs were established for Reservoir A1 and the Acadia Recreational Reservoir to assist in assessing infrastructure requirements in these locations.

The lack of stream flow stations in the area, coupled with the short period of available record and numerous zero runoff years made it difficult to determine peak flow estimates for this area. A number of hydrological methods and analyses were completed, including a regional analysis utilizing five WSC stations from the general area; a single station analyses with Kennedy Coulee recorded data; a single station analysis with Kennedy Coulee extended with Alkali Creek; and a single station analysis on Alkali Creek.

The results of these analyses were sporadic; however the single station analysis of the Kennedy station, with the period of record extended to 41 years using the Alkali Creek station, was selected to generate peak flood estimates for the 1:100 and 1:1,000 year return periods. A linear regression analysis on the maximum daily flow was utilized to extend the Kennedy station data. An adjustment for the zero flow data in the Kennedy period of record was completed using a method recommended in the 1999 Alberta Transportation Flood Frequency Guidelines.

The resulting peak flow estimates for the Kennedy WSC station were utilized for Acadia Recreational Reservoir and transferred to Reservoir A1 (using a drainage area ratio raised to exponent of 0.8). Flood volumes were determined for the various return periods and the hydrograph shape was generated using an AENV standard dimensionless hydrograph created for Prairie Streams.

The peak flow estimates and flood volumes for the 1:100 and 1:1,000 year return periods for the Acadia Recreational Reservoir and Reservoir A1 are provided in Tables 5.2 and 5.3. Refer to Appendix D for further information.

Table 5.2
Acadia Recreational Reservoir (GDA = 939 km^2)

Return Period	Peak Flow Estimates		Flood Volume
	Max. Daily	Max. Instantaneous	
1: 100 yr.	60 m^3/s	105 m^3/s	18,900 dam^3
1:1,000 yr.	96 m^3/s	169 m^3/s	30,400 dam^3

Table 5.3
Reservoir A1 (GDA = 99.5 km^2)

Return Period	Peak Flow Estimates		Flood Volume
	Max. Daily	Max. Instantaneous	
1: 100 yr.	10 m^3/s	17.4 m^3/s	3,115 dam^3
1:1,000 yr.	16 m^3/s	28.1 m^3/s	5,040 dam^3

6.0 WATER AVAILABILITY AND WRMM MODELLING

6.1 General

As discussed in Section 5, the surface water runoff into the proposed storage reservoir varies considerably from year to year and cannot be relied on to meet (in whole or part) the irrigation demand requirements for any of the development scenarios. Therefore; it was assumed that the primary source of water for this project is diversion from the Red Deer River.

This section provides a brief summary of the criteria, assumptions and results of modelling that was completed for the project development scenarios, including modelling of the Red Deer River water availability. A detailed review of the WRMM simulations is provided in Appendix E.

6.2 Supply Flows

In order to determine the impacts that the proposed irrigation development scenarios would have on water availability in the Red Deer River, AENV completed simulations using their South Saskatchewan River Basin (SSRB) Water Resources Management Model (WRMM).

The SSRB simulations incorporated the following information / assumptions:

1) The model included all existing water license allocations, as well as any current applications, within the river basin (updated to 2004). This included the SAWSP application for 76,500 dam^3, as well as 8,093 ha. (20,000 acres) of irrigation development for the Deadfish/Sheerness irrigation project. However, the impact of this project on existing junior licensees relying on Dickson storage was not evaluated.

2) The WCO (water conservation objective) that was used in the SSRB modelling for this study was the ***50% IFN***. This was the WCO recommended by the Red Deer River Basin Advisory Committee (BAC) and is further defined as:

   i) For every reach in the Red Deer River from Dickson Dam to the Saskatchewan border, the weekly instream flow requirement was set to 50% of the flow value in that week that provides **full riverine ecosystem protection**; and
   ii) A minimum flow of 16 m^3/s being released from Dickson Dam year-round (every week).

   Full riverine ecosystem protection *is defined as: "a high level of protection" for four instream components (Water Quality; Fish Habitat; Riparian Vegetation and Channel Maintenance).*

3) The modelling took into account apportionment requirements to Saskatchewan and the additional in-stream flow required in the Red Deer River when the Bow and Oldman River contributions are low. However, the impact of this project on existing junior licensees relying on Oldman Dam storage as a result of the apportionment requirement was not evaluated.

4) A modest amount of Gleniffer Reservoir storage (between FSL and the Minimum Fill Curve) was made available to all modelled allocations (existing licenses and future allocations). Thus, water availability to the MD of Acadia irrigation project is somewhat improved by the use of Government storage in the current modelling.

6.3 Simulation Process

As part of the initial "optimization" process completed for this study, SSRB model runs assuming constant diversion rates of 2, 4 and 6 m^3/s were completed. The results from these runs were utilized to optimize the water availability in the River with the diversion rate and off-stream storage requirement for various irrigation development scenarios. For modelling purposes, a weighted annual demand deficit of equal to or greater than 100mm, was assumed to be acceptable no more than 10% of the time (i.e no more than 6 times in 68 years of model years). This deficit criteria is similar to what was used for SAWSP and other irrigation block modelling used for SSRB planning. The results of this initial optimization process are summarized in meeting minutes MM02, Appendix C. In short, it was determined that the optimal river diversion rate was 2 m^3/s for Scenario 1 (5500 ha); and 4 m^3/s for Scenarios 2 & 3 (8,904 ha & 10,927 ha).

A project WRMM model was setup for each of the three development scenarios, incorporating the assumptions and criteria as outlined in Appendix E. Initial runs utilized the time series values of available supply flows from the River as established from the SSRB simulations. This supply flow information assumed a constant diversion rate. However, this constant diversion rate is often higher than the demand (i.e the reservoirs are full and the diversion rate is higher that the flow rate required to meet irrigation demand). Therefore, any available, but unused water from the River was transferred at the supply point to a separate file.

After the project infrastructure components and WRMM model were finalized for each of the development scenarios, the "actual" weekly required diversion from the River was developed. This was accomplished by subtracting the unused flow (Diversion Channel 10) from the constant diversion rate. The "actual" weekly diversion requirements for the three development scenarios were re-entered into the SSRB model. The water availability files obtained from these final SSRB runs were in-turn re-entered into the project WRMM models to produce the final model results, complete with project deficits.

6.4 Project WRMM Model

This section provides a brief summary of the main criteria and assumptions used for the three development scenarios for this study. See Appendix E for detailed information, as well as system layout schematics and model input tables.

A summary of the main model input parameters are:

- The simulation period for the modelling was from 1928 to 1995. It was assumed that diversion from the Red Deer River began in week 16 (April 16th) and ended in week 43 (October 28th), of each year.

- Irrigation demand started at week 17 (April 30th) and ended at week 40 (October 7th).

- Three reservoir nodes were incorporated into the model for all of the development scenarios:

  i) Reservoir A1 - Main storage reservoir to offset diversion shortages and balance variations in irrigation demand.
  ii) Upstream Reservoir - Coulee storage in the tributary upstream of Reservoir A1 (is not used for irrigation storage but collect runoff water upstream of the West Dam on Reservoir A1.
  iii) Acadia Recreational Reservoir – Existing reservoir on Kennedy Coulee. Not used for irrigation storage; only used as a sump for pump systems supplying irrigation Blocks 3 & 4.

- Runoff into the reservoirs were only considered in the spring (refer to Appendix D Hydrology). Spring runoff flows were calculated (Naturalized flows minus consumptive use), and distributed over a three week period in the spring (last week of April to mid-May).

- Runoff water collected in the Upstream Reservoir (coulee upstream of West Dam on Reservoir A1) is pumped into Reservoir A1 at a maximum rate of 0.5 m^3/s. Pumping occurs at the beginning of the irrigation demand period and empties the coulee by mid-May during most runoff events.

- In order to store the winter precipitation and local spring runoff in the reservoirs (and take advantage of the water for irrigation), the winter water level in the reservoirs was maintained at 0.3m below full supply level (FSL). This also minimizes spill out of the reservoir outside of the irrigation season.

- Net evaporation is considered in all reservoirs. Seepage out of Reservoir A is assumed. An arbitrary (constant) rate of 0.008 m^3/s was used, which equates to 0.3 m at FSL in the reservoir.

- Acadia Recreational reservoir is assumed to be kept at a constant elevation of 0.3 to 0.5 m below FSL in order to minimize spills in Kennedy Coulee due to irrigation demand fluctuations out of the reservoir.

- There are two main delivery systems out of Reservoir A1; Secondary A Canal and Secondary B Pipeline. Secondary A is a gravity canal that feeds Block 1A, as well as delivers the demand requirements for Blocks 3 & 4 to the Acadia Recreational Reservoir. Evaporation and seepage considerations for this canal were incorporated into the IDM irrigation demand files developed by AAFRD. No return flow has been allowed for at Acadia Reservoir, because of the irrigation demand to Blocks 3 & 4.

- Secondary A Canal branches off and gravity feeds Block 2 via a siphon through Kennedy Coulee (For Scenario 2 & 3 only). Return flows via a tailout to a tributary to Kennedy Coulee was incorporated into the model, near the end of the canal. Return flows were developed by the AAFRD IDM modelling and determined that the return flows would be relatively insignificant (average annual flows of 0.11 to 0.13 m^3/s).

- Secondary B is a closed pipeline system that feeds Block 1B.

- The AAFRD IDM model assumed that irrigation Blocks 1A, 1B and 2 would be gravity fed via pipeline laterals to each quarter section and then the farmer would pump to his pivot. The two irrigation blocks that are fed out of the Acadia Recreational Reservoir (Blocks 3 & 4) were assumed to have pipeline laterals run directly to the centre of each pivot and would be fed via pump systems with adequate pressure to irrigate through each pivot (i.e on-farm pumping is not required).

- Reservoir A1 cannot be drawn below elevation 715m. This is to accommodate gravity flow out of the reservoir for the downstream systems. Full irrigation design flow can be provide above elevation 717 m, and reduced capacity out of the structures is available below 717m. The proposed FSL's and storage capacities for Reservoir A1 are provided in Table 6.1.

Note: FSL = Full Supply Level
LOL = Low Operating Level
MOL = Minimum Operating Level

Table 6.1
Reservoir A1 Operating Characteristics

Scenario	FSL (m)	LOL (m)	MOL (m)	Live Storage (above MOL) (dam^3)	Dead Storage (below MOL) (dam^3)
1	723	717	715	7,951	5,500
2	726	717	715	12,300	5,500
3	728.5	717	715	17,038	5,500

6.5 Simulation Results

Figures 6-1, 6-2 and 6-3 show the weighted average annual demand and deficits (mm) to the entire project irrigation area for the three development scenarios. The annual demands and deficits are aggregated (weighted) by the area of each irrigation block. Performance of the individual blocks was very similar to the project aggregate.

The demand shown on the Figures is the GDD determined by the IDM modeling. Deficits indicate the amount of GDD that could not be accommodated for a specific year. Deficits take into account the annual GDD, runoff, available flow in the Red Deer River, reservoir losses and available reservoir storage carried over from the previous year.

The acceptable deficit criterion was met for all three development scenarios; an annual irrigation demand deficit of 100mm or greater only occurred 6 out of 68 model years (8.8%). The charts also show that the total number of deficit years (any amount of annual deficit) were fairly consistent for all the scenarios, with Scenario 2 being the least at 11 years and Scenario 3 being the most at 14 years.

Table 6.2 illustrates the annual diversion volume over the model period for the three development scenarios.

Table 6.2
Annual Diverted Volumes from the River

Year	Annual Diverted Volume from Red Deer River (dam^3)		
	Scenario 1	Scenario 2	Scenario 3
Mean	21,237	36,132	43,235
Max	30,250	53,424	62,586
Min	6,073	9,518	9,518

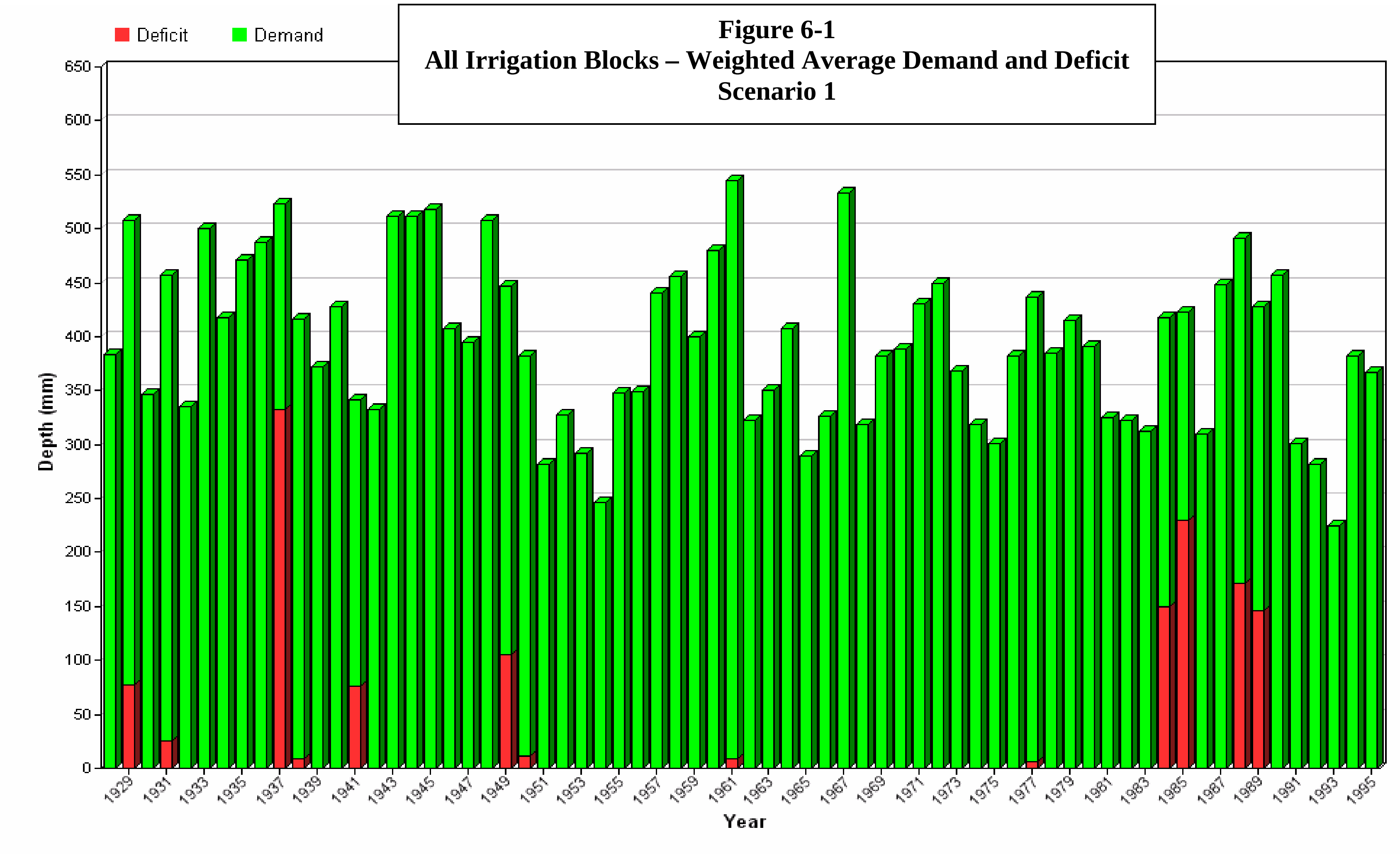
Water levels in Reservoir A1 vary significantly throughout the year, but rarely drop below MOL (715 m). See Appendix E for further information.

The maximum channel flows from the model are summarized in Table 6.3.

Table 6.3
Maximum Flow Rate in Canals and Pipelines

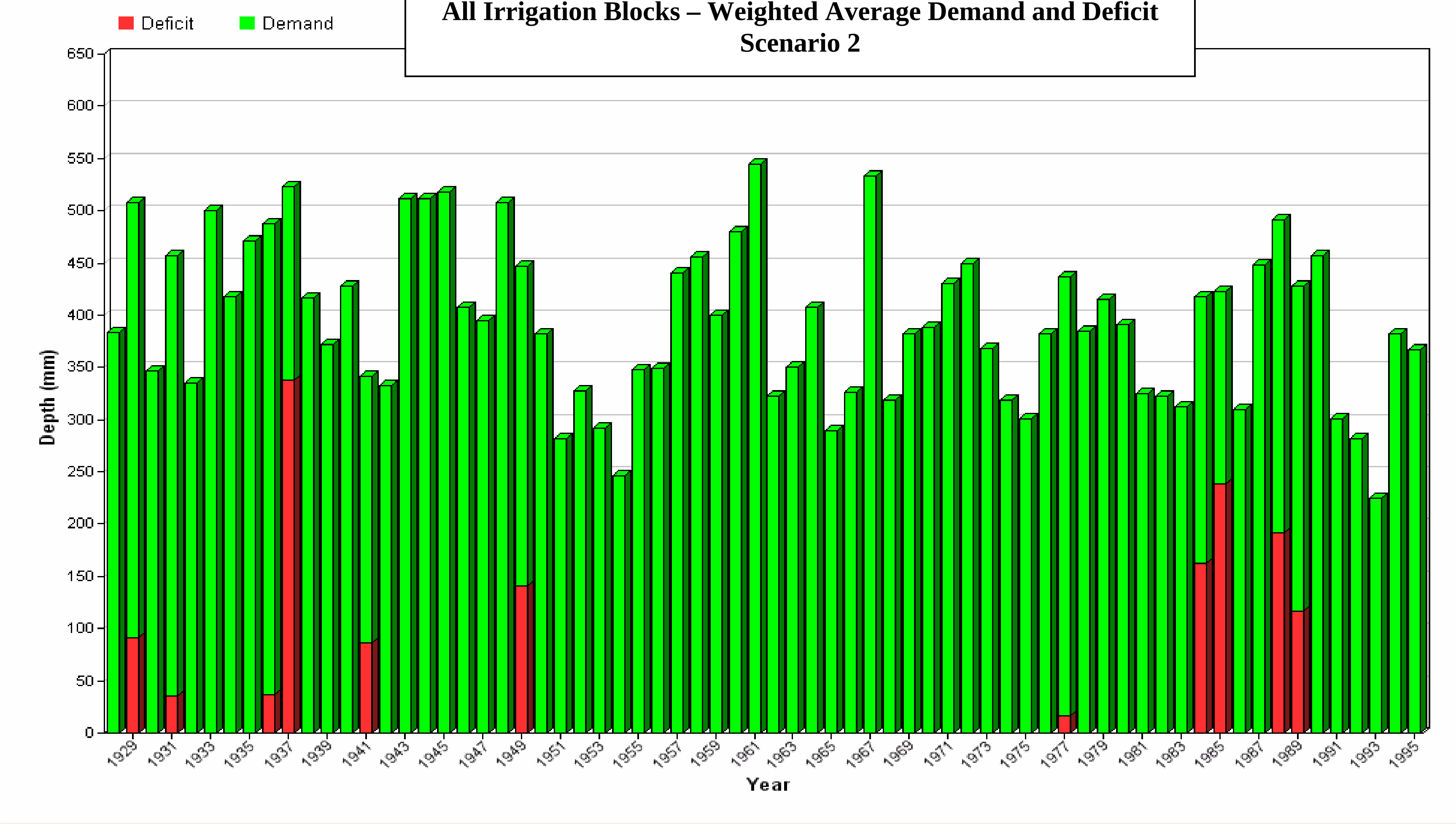
Schematic ID #	Description	Maximum Flow Rate (m^3/s)		
		Scenario 1	Scenario 2	Scenario 3
31	Secondary A d/s of Reservoir A1	1.00	1.00	1.00
34	Secondary B d/s of Reservoir A1	3.25	6.10	7.68
30		2.46	2.46	2.46
45		0.79	0.79	0.79
32	Pipeline to Block 4	0.79	0.79	0.79
47	Secondary A - Syphon to Block 2		2.85	2.85
54	Secondary C Pipeline to Block 3			1.58
33			2.68	2.68
72	Secondary A Canal - Return Flow		0.17	0.17

Figure 6-1
All Irrigation Blocks – Weighted Average Demand and Deficit
Scenario 1



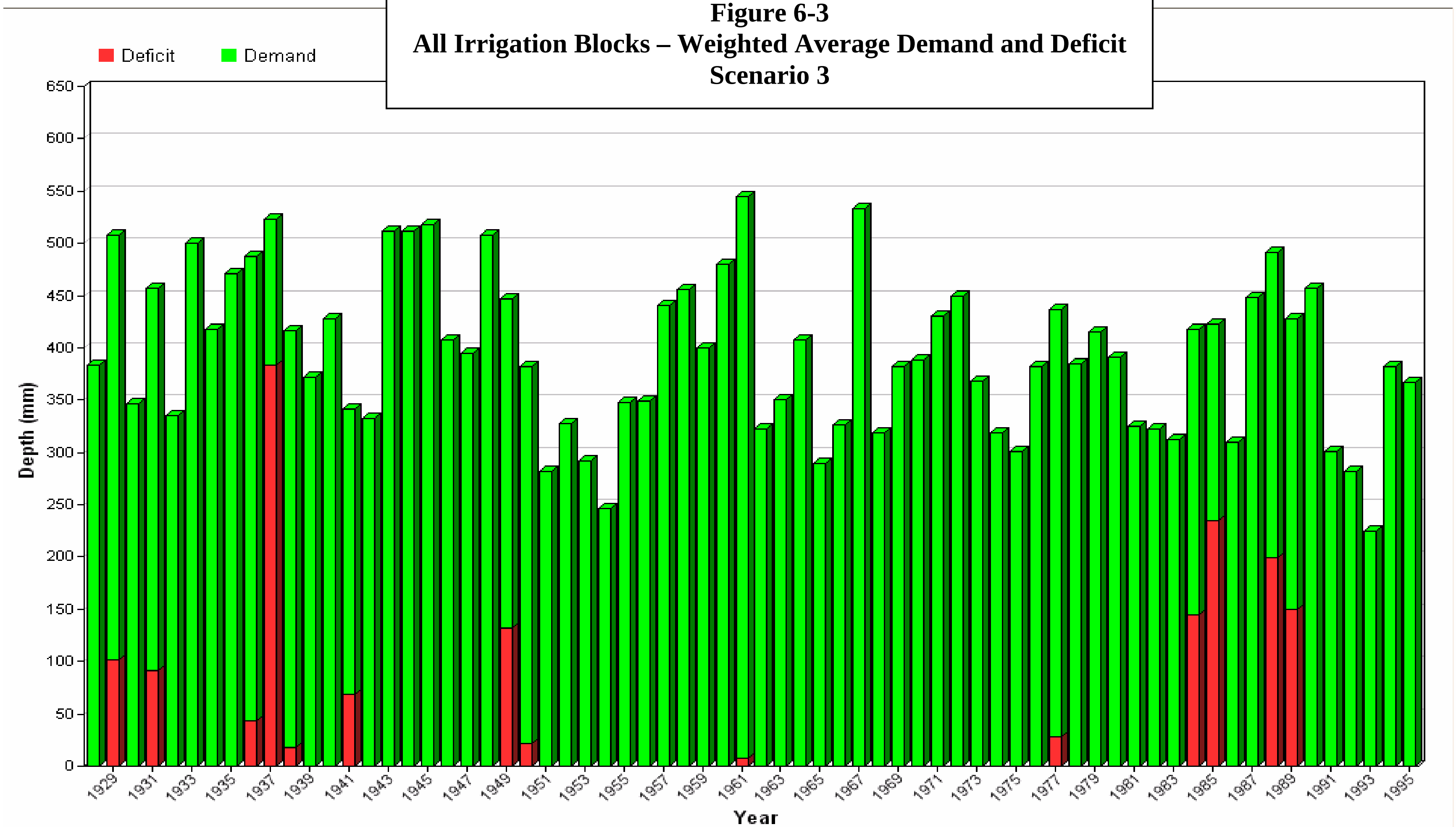
Max. Diversion Rate = 2 m^3/s, Reservoir FSL = 723 m, Live Storage = 7951 dam^3, Total Irrigation Blocks Area = 5500 ha

Figure 6-2
All Irrigation Blocks – Weighted Average Demand and Deficit
Scenario 2



Max. Diversion Rate = 4 m^3/s, Reservoir FSL = 726 m, Live Storage = 12,300 dam^3, Total Irrigation Blocks Area = 8,904ha

Figure 6-3
All Irrigation Blocks – Weighted Average Demand and Deficit
Scenario 3



Max. Diversion Flow Rate = 4 m^3/s, Reservoir FSL = 728.5m, Live Storage = 17,038 dam^3, Total Irrigation Blocks Area = 10,927 ha

7.0 CONCEPTUAL DESIGN

7.1 General

This section describes the system components and infrastructure that would be required for the three irrigation development scenarios described in Section 4 and illustrated on Figures 4-3, 4-4 and 4-5.

As discussed in Section 4.3.1, the infrastructure requirements for the three selected alternatives were determined based on the optimization of a number of factors, including: water availability; various infrastructure options; and capital & operation costs. Table 7.1 summarizes the three development scenarios and main system components.

Table 7.1
Summary of Irrigation Scenarios

Description	Scenario 1	Scenario 2	Scenario 3
Irrigated Area			
• Irrigation Blocks	Blocks 1A; 1B & 4	Blocks 1A; 1B, 2 & 4	Blocks 1A; 1B, 2, 3 & 4
• Total Irrigated Area	5,500 ha (13,600 ac)	8,900 ha (22,000 ac)	10,850 ha (27,000 ac)
Diversion Works			
• Max. Diversion Rate	2.0 m^3/s	4.0 m^3/s	4.0 m^3/s
• Static Lift	130 m	132 m	135.5 m
Storage Reservoir A1			
• Max. Dam Height	25 m	28 m	30.5 m
• Live Storage @ MOL	8,000 dam^3	12,300 dam^3	17,000 dam^3
• Dead Storage	5,500 dam^3	5,500 dam^3	5,500 dam^3
• Area @ FSL	132 ha	148 ha	219 ha
Acadia Reservoir – Used as Sump for Block 3 & Pump Systems			
• Live Storage	Negligible	Negligible	Negligible
• Operation Range	0.3 – 0.5 m below FSL	0.3 – 0.5 m below FSL	0.5 – 1.0 m below FSL
Main Delivery Systems			
• Secondary A - Canal	Block 1B & Acadia Resv. – gravity fed	Block 1B, 2 & Acadia Resv. – gravity fed	Block 1B, 2 & Acadia Resv. – gravity fed
• Secondary B - Pipeline	Block 1A – closed gravity	Block 1A – closed gravity	Block 1A – closed gravity
• Acadia Pump Systems	Block 4 - pressurized system	Block 4 pressurized system	Block 3 & 4 - pressurized system.

Notes: 1) A siphon is used to feed irrigation Block # 2 in Scenario 2 & 3, via gravity.

The following provides a description of the main system components and infrastructure considerations.

7.2 Supply System

7.2.1 River Diversion Works

7.2.1.1 Location

A single river intake is required for all three development scenarios. The general location of the intake was somewhat restricted by the location of the storage reservoir. It was determined to be important from an economic perspective, to locate the intake as close as possible to the Reservoir, but still take into account river morphology and the route of the supply pipeline up the river bank.

7.2.1.2 Diversion Facility

There are a number of existing diversion facilities on the Red Deer River, some of which are owned by AENV. As part of this study, the Deadfish diversion facility was reviewed and discussions were held with various AENV staff on some of their other facilities. In general, the performance of the AENV diversion facilities on the Red Deer River has been mixed and based on these experiences; the following main issues need to be considered in the future design of a river intake for this project:

1) High sediment load – The study area is located downstream from Drumheller, where the lands in and around the river valley are quite susceptible to surface erosion. This can result in high sediment loading in the river during periods of high run-off. This in turn contributes to significant sediment deposits in certain areas, especially where lower flow velocities occur (i.e. inside curves). Locations where the intake is on an outside curve (higher velocities), in the thalweg of the river and where there is general higher velocity and deeper water sections appear to be the most functional.

   For Acadia, the diversion site is proposed along a reasonably straight reach of river near the end of a large outside curve (Refer to Figure 4-3). Intake pipes will protrude into the thalweg of the river and erosion protection will be provided upstream and downstream of the diversion point to help stabilize the bank in this area. A two-chamber wet well will be utilized, with the first chamber providing settling of suspended sediment; and the second chamber being the pump chamber.

2) Fishery consideration – The protection and accommodation of fish will be a major consideration for the proposed intake. Various types of intake configurations; screens (fixed, traveling, drum etc.); and/or fish pumps have been utilized on other facilities; with varying results. The use of fixed or traveling screens has often been problematic and fish pumping is extremely expensive and will be avoided if possible. Some of the more successful applications use drum screens

on the intake pipes or locate the intake structure right at the river's edge with a deep trough below the structure and a fixed screen in the wet well.

The most ideal configuration and specific intake details for the Acadia project cannot be defined at this level of study. Further assessment (survey; geotechnical; sediment monitoring; fisheries assessment; and scour and sediment deposition modelling; etc.) will be required in future design stages. For the purposes of this study, an adequate cost allowance for drum screens (with air scour) has been considered.

3) Debris and Aquatic Weeds – This is often accommodated in the facilities that are used to address the fishery issues. Trash racks on the intake are required and some form of traveling or drum screen (with air scour) is most commonly used. Fixed screens usually plug up and traveling screens require high maintenance and can be tough on fish. Drum screens with air scour have been used effectively and will be assumed for this application for the purpose of this study.

7.2.1.3 River Pump Station

Based on the WRMM modelling, it was determined that the intake facilities would be designed to divert a flow rate 2.0 m^3/s (31,700 USGPM) for Scenario 1 and 4.0 m^3/s (63,400 USGPM), for Scenario 2.

The diverted flow is pumped to a storage reservoir (Reservoir A1). The pumps are designed to lift the water from river level to the full supply level in the reservoir, with a total dynamic head of approximately 160-165 metres (static head plus pipeline friction losses).

The flow rates combined with the high total dynamic head requires that multiple, large horsepower pump be used, which in turn results in high energy demands. Various combinations of pump size vs # of pumps were considered. The most economical pump configuration (based on capital and long-term energy costs) was selected, as per Table 7.2.

Table 7.2
Pump Requirements

Scenario	Diversion Rate	Pumps		Total Installed Horsepower
		No. & Size	Horsepower	
1	2	Four – 600mm dia.	1,500 Hp / each	6,000 Hp
2	4	Seven – 600 mm dia.	1,500 Hp / each	10,500 Hp
3	4	Seven – 600 mm dia.	1,500 Hp / each	10,500 Hp

** All pumps are vertical turbine pumps high thrust motors

The pump wet well will be a 13 m high, pre-cast, reinforced concrete tank, with two chambers, as discussed in Section 7.2.1.2. The pump station is assumed to be a combination of concrete block and pre-finished metal cladding on a steel frame. The footprint for the pump station is 464 m^2 (29 m by 16 m). The width of the wet well is governed by the required number of pumps on the main floor.

The pumps are designed to be installed on the pump station main floor with the intake shafts down into the wet well. The pump intakes would be set a minimum of 1m above the invert of the wet well. The invert of the wet well is set low enough to maintain at least 5m of water in the wet well to provide adequate pump suction submergence.

The discharge side of the pumps would be connected to a main pipe header equipped with control valves. The discharge header would connect to the main supply pipeline.

The pump house would be equipped with steel support beams for an overhead crane to facilitate the pump installation and removal. The pump house would also contain an operating control room as well as electric switch gear, motor starters etc. The building is supplied with natural gas service for the building heating system.

7.2.2 Supply Pipeline

The river valley in the vicinity of the proposed storage reservoir has steep and rough banks. Evidence of erosion and possibly sloughing of the river bank exists (Refer to Photo #1 in Appendix B). There are not many suitable pipeline alignments out of the river valley in the general location of the Reservoir. Careful routing and significant geotechnical assessment will be required to determine the most suitable and cost effective alignment in later design stages. For the purposes of this study, a pipeline alignment and intake location was picked based on a preliminary site evaluation and review of aerial photography (See Figure 7-1 and Photo 2 in Appendix B).

Large diameter pipe is required to accommodate the high diversion rates, and the pipeline is subjected to high pressure because of the static lift required to pump the diverted flow out of the river valley. This combination (large diameter pipe and high pressure requirements) precludes the use of PVC pipe and limits the pipe material selection to either steel or concrete. Due to the nature of the terrain (especially from the pump station in the valley and up the river bank), steel is the preferred material choice. Once the pipeline has reached the top of the river valley, the static head (and related operating pressure) is substantially reduced.

The supply pipeline is assumed to be a welded steel pipeline, 1067mm (42”) diameter for Scenario 1 and 1220 mm (48”) diameter for Scenarios 2 and 3. The flow velocities in the pipe under full design flow are 2.6 m/s and 3.0 m/s respectively. Due to the high flow velocities, provisions have been made for surge protection at the pump station and thicker pipe walls have been selected (XS).

7.3 Storage Reservoirs

7.3.1 General

Numerous sites within the study area were considered (as well as multiple site locations), in the initial optimization of development scenarios, as discussed in Section 4. However; a single storage reservoir site (Reservoir A1), was selected for all three development scenarios. The storage requirement for the reservoir was based on optimization of diversion rate, river water availability and reservoir storage in the WRMM modelling for the project (Section 7).

The existing Acadia Recreational Reservoir will be used as a pump station sump for pressurized systems feeding Blocks 3 & 4; however it has insufficient capacity to be used as a storage reservoir.

Specific site information and component descriptions for the two reservoirs are provided below.

7.3.2 Reservoir A1

The basic characteristics of Reservoir A1 are shown in Table 7.3.

7.3.2.1 Site Location

An un-named tributary to Kennedy Coulee (from the west) was selected for the main reservoir site. This tributary provides a coulee with sufficient storage to economically supply the requirements of all three irrigation scenarios. This location was also close to the Red Deer River and was high enough in elevation to allow gravity distribution to all irrigation blocks except for Block 3 & 4.

The selected site for the reservoir within the tributary is shown on Figure 7-1. Two dams are proposed to contain the reservoir. The main dam is located at the east end of the reservoir (East Dam) and a smaller dam at the upper end of the reservoir (West Dam). Refer to Photo’s 5 & 6 in Appendix B for the general layout of the reservoir and proposed West Dam location.

The surficial geology and bedrock mapping that was reviewed for this study (Section 3) indicates that the material in this area is basically a till, consisting of deposits of silt and clay with some sand and gravel in the valley. Bedrock depth appears to be in the order of 15 to 25m below surface. Although no major concerns are apparent, the geological mapping by itself is not conclusive in terms of the sites suitability as a storage reservoir and the suitability of the dam sites to support large embankment structures.

Table 7.3
Reservoir A1 Characteristics

Description		Unit	Quantity		
			Scenario 1	Scenario 2	Scenario 3
Reservoir	FSL	m	723	726	728.5
	Capacity @ FSL	dam^3	7,200	12,300	17,000
	Area @ FSL	km^2	1.32	1.62	2.19
	Maximum Length	km	3	3	3
	Average Width	km	0.5	0.54	0.6
	Max. Depth @ FSL	m	23	26	28.5
East Dam	Top of Dam	m	725	728	730.5
	Max. Height of Dam	m	25	28	30.5
	Crest Length	m	1630	1865	2100
	Crest Width	m	6	6	6
	Freeboard @ FSL	m	2	2	2
West Dam	Top of Dam	m	725	728	730.5
	Max. Height of Dam	m	9	12	14.5
	Crest Length	m	235	290	330
	Crest Width	m	6	6	6
	Freeboard @ FSL	m	2	2	2
Secondary A Canal Outlet Structure	Conduit Dimension (W * H)	mm	1220 * 1220	1830 * 1830	2130 * 2130
	Conduit Length	m	130	150	160
	Capacity @ Operation Level	m^3/s	3.25	6.1	7.5
Secondary B Pipeline Outlet Structure	Conduit Dimension (D)	mm	1200	1200	1200
	Conduit Length	m	140	160	170
	Capacity @ Operation Level	m^3/s	1	1	1

The West Dam is required in order to limit permanent flooding in the coulee west of the MD Boundary. This is because a portion of the upstream coulee swings sharply towards the River and is in very close proximity to the sharp escarpment known as Dune Point Springs (Refer to Figure 7-2). At the closest point, the tributary coulee is only ±300 m from the top of the bank of the Red Deer River. A review of air photos and available geology information suggests that the River has been subject to bank erosion and movement. In addition, layers of sands and gravels are prevalent in the area and the reservoir water levels would be considerably higher than the River. Therefore, seepage from the coulee is quite possible, which in turn could lead to bank instability and sloughing concerns on the river valley slopes. This is of particular concern in locations where the tributary coulee is in close proximity to the River, and for this reason the limited set back available in the tributary coulee, west of the MD boundary, was considered an unacceptable risk. This location should be assessed further for geotechnical implications during later design stages to verify the assumptions made. Therefore, for the purposes of this study, the dam locations have been selected such that the reservoir has a minimum setback of 800 m from the river bank. This setback consideration has resulted in the requirement to include the construction of the upstream (west) dam in order to confine the reservoir.

The location of the West Dam has been selected to take advantage of localized higher ground in the coulee, reducing the amount of earth fill required.

Although the West Dam prevents permanent flooding in the upstream tributary, water will be trapped upstream of the dam during significant runoff events. It was determined however (Section 5); that runoff is sporadic in this area and usually restricted to snow melt events. Spring runoff volumes that would enter the coulee upstream of the West Dam were estimated for the WRMM modelling and it was determined that the West dam would not overtop based on the 68 year period of record from 1928 – 1995. In order to take advantage of the runoff water for irrigation, and to avoid prolonged flooding within the coulee upstream of the West Dam, a small pump station will be provided at the West Dam. The pump station will transfer water collected upstream of the dam into the reservoir, after spring runoff is complete and irrigation demand has started. It is anticipated that the pump station will only operate in the spring and some years not at all. The pump station is sized to ensure the coulee upstream of the dam is emptied by early to mid-May of each year.

7.3.2.2 Embankments

Both of the reservoir embankments were assumed to be a zoned earthfill with an impervious core and semi pervious / pervious outer shells utilizing construction materials available from borrow sources within the general vicinity (+/- 2 km.), of the dam sites.

The design criteria for the embankments were taken from USBR, USACE and in particular, the Canadian Dam Safety Guidelines (CDA).

The East Dam is approximately 1850 m long with a maximum dam height of 25 to 32.5 m, depending on the development scenario. Geotechnical information was not available for the dams, therefore a generally conservative dam cross-section was assumed because of the large height of fill. The dam footprint was based on theoretical side slopes of 6H:1V, with the actual cross-section using 3H:1 Vertical side slopes with berms at 1/3 of dam height increments extending the cross-section to the theoretical 6:1 slope line. The dam cross-section also includes a 4m deep impervious cutoff trench, a one metre thick inclined drainage filter and a 2 metre thick filter blanket on the downstream slope. A 700 mm riprap layer over 300mm bedding gravel layer is provided to protect the upstream face against wave action. A vertical freeboard height of 2 meters above FSL is provided for wind/wave action, flood storage and long-term embankment settlement.

The West Dam is approximately 300 m long with a maximum dam height of 9 to 15 m, depending on the development scenario. The dam cross-section was assumed with 3H:1V side slopes on the both the upstream and downstream faces. The dam also includes an impervious cutoff trench, inclined drainage filter, filter blanket and riprap. Freeboard above FSL is 2 meters as per the East Dam.

Refer to Figure 7-4 for typical dam cross-sections.

7.3.2.3 Dam Classification

The West Dam has a maximum height of approximately 12 m (10m water depth at FSL). Although this is a significant embankment, a piping failure of this dam would be contained within the coulee, approximately 6 – 8 km upstream of the dam. A cursory review of available mapping determined that the impacted reach of coulee is un-inhabited and although some pasture land and minor utility and agricultural infrastructure may be affected, the damages resulting from a breach of the West Dam are considered relatively minor.

The East Dam would be a significant structure with a maximum height of 25 to 30m and a water depth of 23 to 28m at FSL. A failure of this dam would cause a significant flood wave and possibly impact farmsteads near the Red Deer River. Therefore, a cursory review of the potential consequences that would occur due to a dam breach failure was conducted on the East Dam. This review utilized NTS mapping and was based on the dam configuration required for Scenario 2. The breach width was assumed to be equal to the height of the dam (28 m wide), with 1:1 side slopes. The peak breach flow at the dam was estimated at 11,000 m^3/s.

The flood wave from a breach of the East Dam would travel down the un-named tributary, into Kennedy coulee and then proceed to the Red Deer River. A ranch site with several residents is located within the Red Deer River flood plain, near the location where the flood plain would enter the River. However, contour mapping suggests that this site would not be significantly impacted. This would have to be confirmed in later study stages. The dam breach flood wave would impact three municipal roadways and inundate cultivated and pasture lands. Oil infrastructure would also be impacted as well as significant environmental and historical sites. In addition, a dam failure would result in loss of the reservoir storage and prevent the ability to operate the irrigation system for up to a 2-3 years period. Potential impacts along the Red Deer River are also likely, but were not investigated.

In accordance to the CDA Guidelines, when fatalities are not anticipated and other damages are considerable, but not severe; the dam should be classified as “Low”. In addition, the Guidelines indicate that the inflow design flood (IDF) for a “Low” consequence dam should be in the range of the 1:100 to 1:1,000 year flood event. Since this dam would be a very significant structure and considerable economic, environmental, agricultural and historic site damages would occur, the upper end of the IDF range is appropriate. Therefore; the East Dam was assumed to be a “low” consequence dam with an IDF = 1:1,000 year flood. Note: It would be essential that the flood plain associated with a potential East Dam failure be delineated and future development within that area be restricted to ensure that future residents are not put at risk, if this reservoir is constructed.

7.3.2.4 Spillways

Section 5 determined that the anticipated runoff volume from a 1:1,000 year flood event was just over 8,000 dam^3. This is relatively insignificant and can be stored within the coulee upstream of the West Dam. As a precaution, an earthen overflow section will be provided at the West Dam to allow runoff into the reservoir in the event of a severe runoff condition. In addition an emergency spillway channel will be located at the SE end of the reservoir (around the East Dam) at an elevation of 1m below top to dam. This can be incorporated into the borrow requirements for the dam.

7.3.2.5 Structures

Two low level outlet works were designed to provide water requirements for the Secondary A Canal and Secondary B Pipeline.

The Secondary A Canal outlet structure is located at the north side of the East Dam. The outlet structure is approximately 150 meters in length, and consists of a 1830 *1830 mm cast-in-place concrete conduit with an inlet, a gatewell, heavy duty sluice gate and outlet stilling basin. The outlet works design capacity is $6.1m^3/s$ with the reservoir at the low operating level of 717 m.

The Secondary B Pipeline outlet structure is located at the south side of the East Dam. A 160 m long, 1200 mm diameter, reinforced concrete pipe with an inlet, concrete gatewell and heavy duty sluice gate will be provided. The outlet works design capacity is $1m^3/s$ with the reservoir at the low operating level of 717 m.

Refer to Figure 7-3 for typical structure configurations.

The West Dam pump station will consist of a vault with a single, three-phase submersible pump, mounted on guide rails to facilitate servicing.

7.3.3 Acadia Recreational Reservoir

The study committee had requested that consideration be given for additional irrigation development around the existing Acadia Recreational Reservoir. This reservoir is located in SW¼ section 5 Township 25 Range 2 W4. The reservoir was developed in 1982/1983 for recreational purposes. The reservoir itself is not very large (150 dam^3 at Full Supply Level). Operating the reservoir as a balancing water supply for irrigation purposes would result in large fluctuations in water levels, something that is considered undesirable since the primary purpose of the reservoir is recreational. The reservoir will be utilized as a sump, to supply water to a new pump station that would pump water to a secondary distribution system (pressure-pipeline). The main irrigation water supply (Secondary A-canal) would supply sufficient water to the Recreational Reservoir to offset the pumped flows so that the reservoir level would not fluctuate by more than 0.3 – 0.5 m.

The pump station on the Acadia Recreational Reservoir is proposed to be developed on the east side of the reservoir. The existing reservoir would require minor, local dredging work to ensure adequate water depth to supply the pump station.

The pump station would include a cast-in-place wet well with a concrete block building on top at ground level. The pumping equipment includes two 450 mm (18") diameter three-stage vertical turbine pumps. The pumps would be connected to a variable frequency drive (VFD) to be able to gradually adjust the pump speeds to varying flow conditions.

The Acadia Reservoir is located right on Kennedy Coulee and can experience significant runoff flows. The 1:1,000 year flood event in this area was estimated to be 169 m^3/s (approximately four times the peak flow experienced in 1997). The existing structure appears to have capacity to pass this event at the top of dam elevation; however, the dam would likely be at risk. Since the existing dam is not essential for the irrigation works (only a pump sump is required), the safety and classification of the dam as well as any upgrades or improvements required was not considered as part of this study.

7.4 Water Distribution System

7.4.1 General

The distribution system consists of one main gravity canal (Secondary A), which delivers water from Reservoir A1 to Block 1A along the west side of Kennedy Coulee and tails out into Acadia Reservoir. A siphon from this canal delivers water across Kennedy Coulee into an extension of Secondary A Canal to feed Block 2 for Scenarios 2 & 3.

Block 1B is gravity fed off of Reservoir A with a closed pipeline system. Block 3 and 4 are fed through pressurized pipelines out of the Acadia Recreational Reservoir, which is in turn fed via the Secondary A canal.

This section provides a brief description of the delivery system required to service the three development scenarios. Refer to Figures 4-3, 4-4 & 4-5 for main canal and pipeline alignments and locations.

7.4.2 Criteria and Assumptions

The following summarizes the basic criteria and assumptions used for the distribution system for the three development scenarios:

1) As a general rule, distribution works were based on the design standard established by AAFRD for irrigation systems in Southern Alberta - "Engineering Standards for Design and Construction of Projects Under the Irrigation Rehabilitation Program". However; the system design flows were based on the results of the WRMM modelling completed for this study (see Appendix E).

2) All delivery channels are plastic lined, except for a 4 km long lateral at the east end of Block 2. This lateral runs south off of Secondary A canal and acts as a system tail-out.

3) Check and drop structures were incorporated along the canals as required to feed the various lateral pipeline turnouts. All check and drop structures > $4m^3/s$; as well as the siphon inlet and outlet structures; were assumed to be cast-in-place concrete structures. All remaining canal and turnout structures were assumed to be pre-cast concrete.

4) All gravity and pressure pipelines for the delivery systems were assumed to be PVC.

5) All lateral for Blocks 1A, 1B and 2 were assumed to be pipelines which provide gravity water delivery to the border of each irrigated parcel (typically ¼ sections). The laterals for the pressurized systems (Blocks 3 & 4) utilize pipelines which run to each pivot centre.

7.4.3 System Infrastructure

A summary of the characteristics for Secondary A Canal is provided in Table 7.4. The pipelines for Secondary B, C, Block 4 and the siphon are described in Table 7.5. Refer to the detailed cost tables in Section I for a listing of the number of structures, length of canals and pipelines, etc.

Table 7.4
Secondary A Canal – Conceptual Design Characteristics

Secondary A Canal	**Length**	**Q**	**Bed Slope**	**Bed Width (B)**	**Water Depth (D)**	**Total Depth**	**B/D**	**N**	**Side Slopes**	**Velocity**
	km	**m^3/s**		**m**	**m**	**m**			**H:V**	**m/s**
Scenario 1	-									
West of Kennedy Cr (out of valley)	3.0	3.25	0.00060	2.80	1.11	1.73	2.5	0.037	2.5:1	0.52
West of Kennedy Cr (remainder)	10.3	3.25	0.00060	2.80	1.11	1.73	2.5	0.037	2.5:1	0.52
Feed to Acadia Reservoir	5.0	1.00	0.00140	1.20	0.65	1.25	1.9	0.037	2.5:1	0.54
Scenario 2	-									
West of Kennedy Cr (out of valley)	3.0	6.10	0.00040	4.00	1.41	2.14	2.8	0.033	2.5:1	0.57
West of Kennedy Cr (remainder)	10.3	6.10	0.00040	4.00	1.41	2.14	2.8	0.033	2.5:1	0.57
East of Kennedy Creek	8.0	2.85	0.00070	2.50	1.04	1.64	2.4	0.037	2.5:1	0.54
Feed to Acadia Reservoir	5.0	1.00	0.00140	1.20	0.65	1.25	1.9	0.037	2.5:1	0.54
Scenario 3	-									
West of Kennedy Cr (out of valley)	3.0	7.50	0.00035	4.50	1.56	2.35	2.9	0.033	2.5:1	0.57
West of Kennedy Cr (remainder)	10.3	7.50	0.00035	4.50	1.56	2.35	2.9	0.033	2.5:1	0.57
East of Kennedy Creek	8.0	2.85	0.00070	2.50	1.04	1.64	2.4	0.037	2.5:1	0.54
Feed to Acadia Reservoir	5.0	2.40	0.00080	2.00	0.99	1.59	2.0	0.037	2.5:1	0.55

Table 7.5
Pipeline Conceptual Design Characteristics

Main Delivery Pipelines	# of Pivots	Main Length km	Max. Design Q m^3/s	Pipe Diameter[1] mm	PVC Pipe Rating	Comments
Block 3 Pressure System	31	13.8	1.23	900 to 250	DR 25 / 26	Pressure is 130 psi @ pump; 40 psi @ pivot
Block 4 Pressure System	19	16.5	0.79	750 - 250	DR 32.5	Pressure is 100 psi @ pump; 40 psi @ pivot
Secondary B Closed Pipeline	25	12.0	1.00	1200 - 300	DR 51 / 41	Feeds Block 1B
Kennedy Coulee Siphon	n/a	3200	2.85	1200	DR 51	Feeds Secondary A canal to Block 2

[1] **Pipe diameter decreases along the pipeline.**

7.5 Alternative Energy Sources

7.5.1 General

This section provides a brief over-view of alternative energy sources for this project. The intent was to investigate potential options of energy supply with the intention of partially offsetting the high pumping costs associated with this project.

Section 7.2 identified the power capacity for the pump diversion from the Red Deer River as approximately 8 mega watts (mw) and the average annual energy requirement at 14 giga watt hours (Gwh). The capacity of 8 mw is very significant; whereas, the annual energy requirement of 14 Gwh is relatively small. This reflects the high head and pumping rate required to supply river diversion water to the reservoir; however, the duration of pumping time is relatively short.

7.5.2 Conventional Power Supply

For this type of project and power requirements of this magnitude, energy is typically supplied by connecting to the existing power grid. This is usually the most easily implemented and cost effective option.

7.5.3 Alternative Power Supply Options

7.5.3.1 General

In recent years, the high cost of conventional power and the advancement of technology and environmental considerations and concerns have led to investigation and implementation of numerous alternate energy sources. Several options for the supply of energy were briefly considered, consisting of:

1. Small on-site hydroelectric plant.
2. Construction of a low head hydroelectric run-of-the-river plant on the Red Deer River.
3. Construction of a wind farm in the area.
4. Purchase of wind energy.

These options are discussed further as follows.

7.5.3.2 Small Scale Hydro

Several small scale hydro projects have been developed on irrigation Headworks or main canal systems in Southern Alberta in recent years. Some examples include:

i) IRRICAN - Raymond Power Plant near Milk River Ridge	-	20 MW
ii) IRRICAN - Chinn Coulee Plant	-	11 MW
iii) IRRICAN - Drops 4,5&6; Smrid Main Canal	-	7 MW

These plants require reasonably high flow and high drop to be efficient. The smallest of the plants listed (Drop 4,5 &6) has a flow of 51 m^3/s with a 15m drop. They are also all connected to the main power grid.

As a revenue generator, this type of development can be cost effective if the hydro project can be implemented into the regular system infrastructure (i.e. large drop structures; high and consistent flow; etc.). The infrastructure for the proposed development scenarios does not support this type of development. Flows for the proposed Acadia system are relatively small (3 – 5 m^3/s) and there is no significant in-line drop structures required in the system. Therefore; this type of development is not considered to be feasible for this project.

7.5.3.3 Low Head Hydro – Run-of-River-Plant

In order to generate energy from the Red Deer River a dam would be required across the river to create an energy head that could be utilized by a run-of-the-river power plant. The 8 mw capacity requirement is significant for a river the size of the Red Deer. The mean monthly flows for June/July/August average approximately 54 m^3/s. A hydraulic head of about 17m would be required to generate the required 8 mw with a flow of 54 m^3/s. The average minimum flow is considerably lower (about 6 m^3/s) for the same period of time. At flows this low, the plant would not be able to operate and energy would be required from the provincial grid in any event.

The concept of constructing a dam on the Red Deer River is fraught with environmental issues and would take a long time and many dollars to go through the application process with no assurance of approval (as has been experience on a proposed recent low-head hydro project on the Peace River, above Dunvegan). Therefore, the hydroelectric option for powering the pumps is not considered practical or feasible.

7.5.3.4 Dedicated Wind Farm

The order of magnitude cost to develop a turbine with a capacity of 1 mw is currently estimated to be about $2.6 million. Therefore, to achieve a capacity of 8 mw a capital cost of about $21 million would be required. Although there is no site data available it is anticipated that the utilization factor in this part of the province could be in the order of 20 percent. It is noted that in the southwestern part of the province in which wind farms have been, and are being developed, the utilization factor is in the order of 35 percent. Consequently the system would have to be connected to the grid and energy purchased.

Currently there are no wind farms in this area of the province. Recent investigations have been carried out just south of the MD; however specific information is not available and significant advancements on this potential wind farm site have not been made. This option is not considered viable.

Considerable investigation and data gathering would be required to determine the feasibility of a wind farm in the MD of Acadia. The MD could consider partnering with an energy developer to investigate this option further, especially since the cost of investigation and implementation would be significant.

7.5.3.5 Purchase of Wind Energy

The purchase of wind energy is an option that has been implemented by others and involves the direct purchase of energy that is generated by a wind energy producer. A well known example of this is the Calgary LRT which advertises that it runs on wind energy. In fact, the user negotiates a contract with the wind energy producer who, in turn, passes the energy into the provincial grid and the user connects to the grid and draws the equivalent energy. This is possible as the provincial and federal governments are very supportive of this type of "green" energy. It also appears that the general public is supportive of wind energy. This option could be investigated further, but is not considered to relate into significant (if any) cost savings for the irrigation project.

7.5.3.6 Summary

For this type of project and with power requirements of this magnitude, energy is typically supplied by connecting to the existing power grid. This is usually the most easily implemented and cost effective option. Consideration could be given to pursuing programs that support the utilization of "green energy", but this is not expected to provide a significant cost savings for the operation of the proposed development scenarios. Low head hydro on the Red Deer River or small scale hydro on the proposed system infrastructure is not considered viable in this area. The development of a wind farm in the area is unproven and if the MD wishes to pursue this further, partnering with an energy producer should be considered.

Therefore; the purpose of this study, the cost of energy utilized was assumed to be supplied by connecting to the existing power grid.

SCENARIO	T.O.D.	F.S.L.
1	725.0 m	723.0 m
2	728.0 m	726.0 m
3	730.5 m	728.5 m

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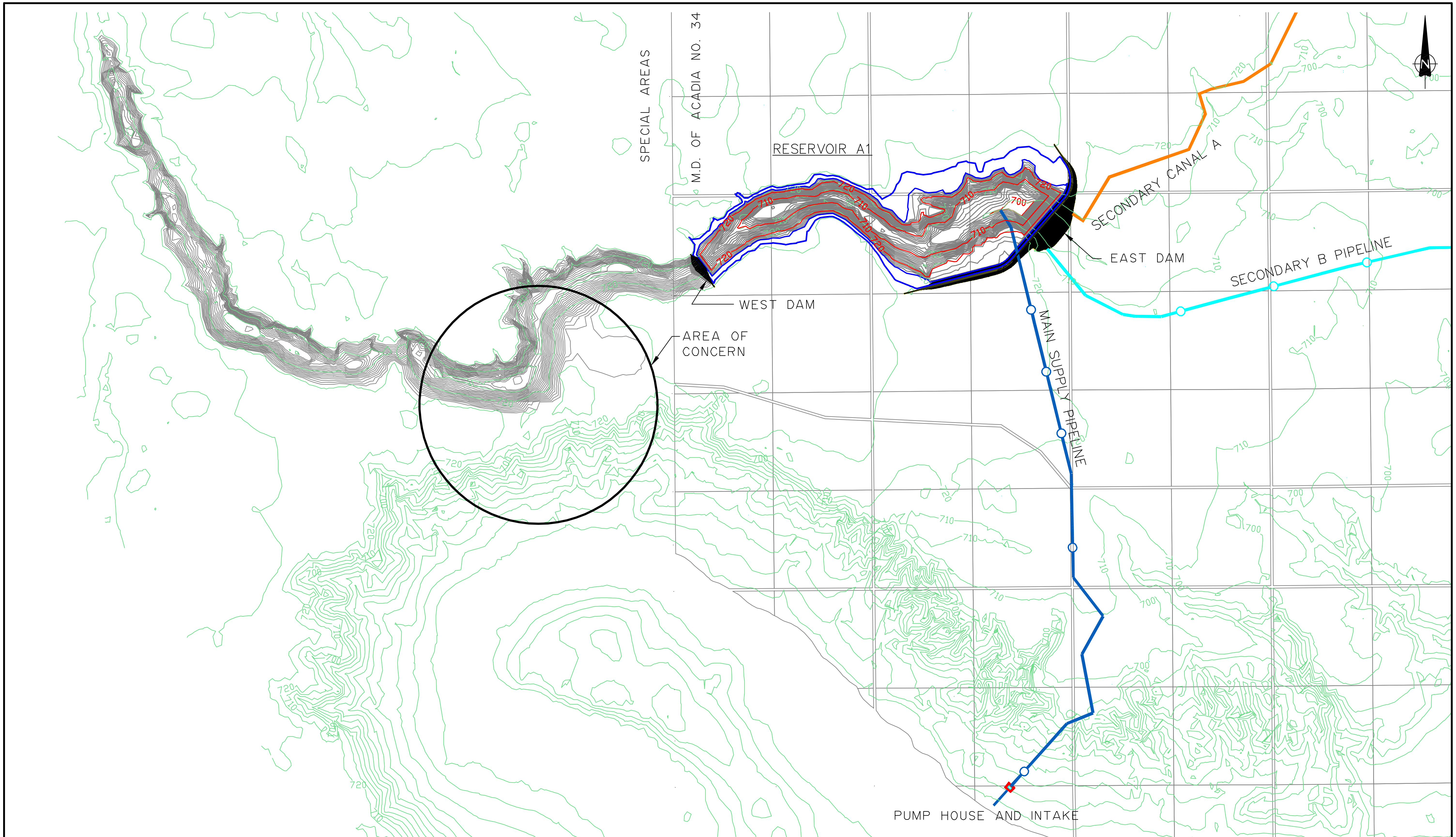
M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY
DIVERSION WORKS / RESERVOIR A1
SITE PLAN

SCALE: 1: 30,000 | DATE: APRIL 2005 | JOB: 2280-001-00 | FIGURE: 7-1



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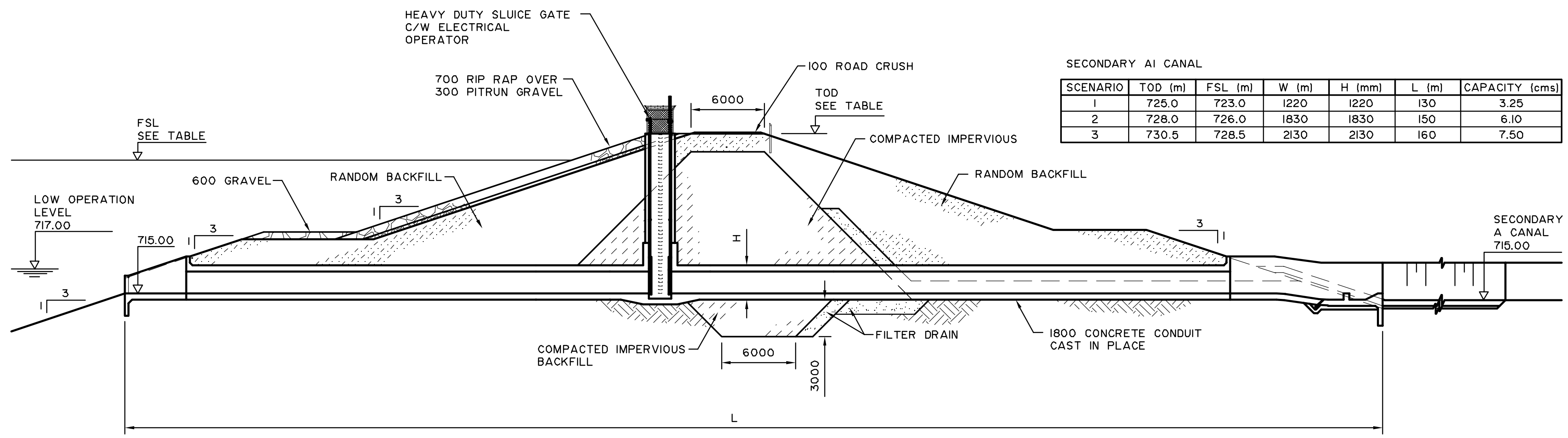
M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY
RESERVOIR SITE
CONTOUR PLAN

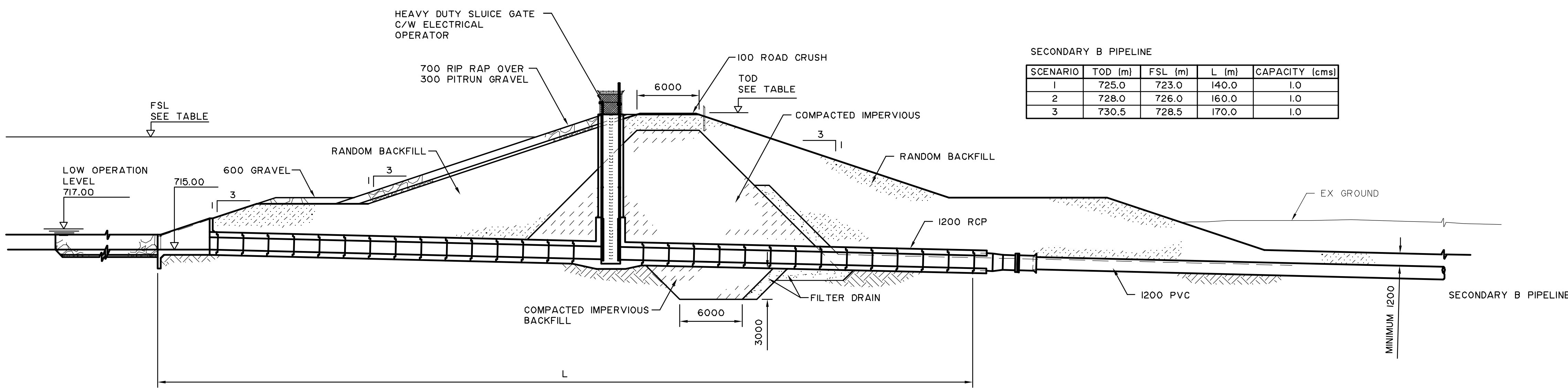
SCALE: 1: 30,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 7-2

SECONDARY A1 CANAL						
SCENARIO	TOD (m)	FSL (m)	W (m)	H (mm)	L (m)	CAPACITY (cms)
1	725.0	723.0	1220	1220	130	3.25
2	728.0	726.0	1830	1830	150	6.10
3	730.5	728.5	2130	2130	160	7.50



SECONDARY A CANAL OUTLET STRUCTURE

SECONDARY B PIPELINE				
SCENARIO	TOD (m)	FSL (m)	L (m)	CAPACITY (cms)
1	725.0	723.0	140.0	1.0
2	728.0	726.0	160.0	1.0
3	730.5	728.5	170.0	1.0



SECONDARY B PIPELINE OUTLET STRUCTURE

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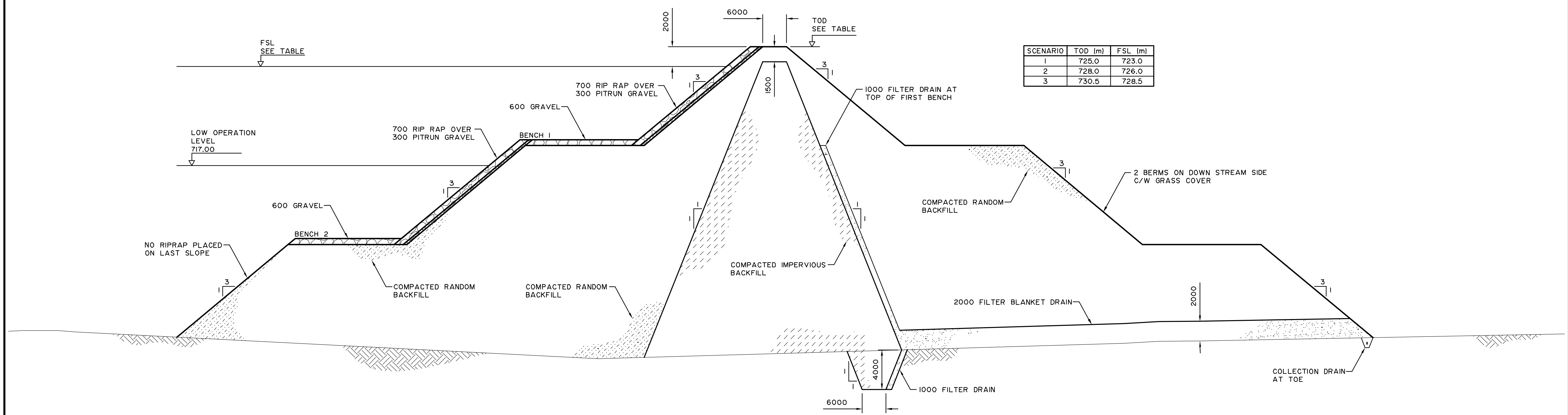
IRRIGATION DEVELOPMENT STUDY
SECONDARY A AND B
HEADWORK STRUCTURES

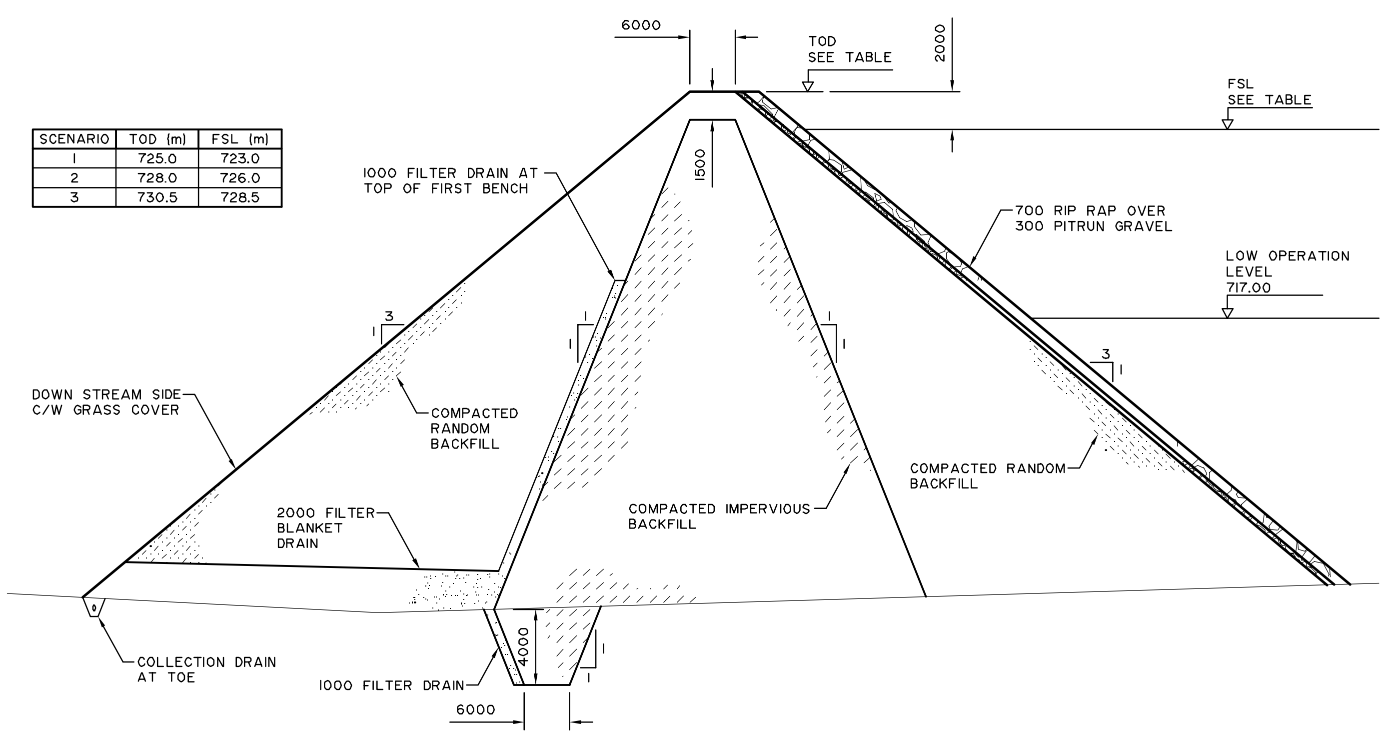
SCALE: 1 : 500	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE 7-3



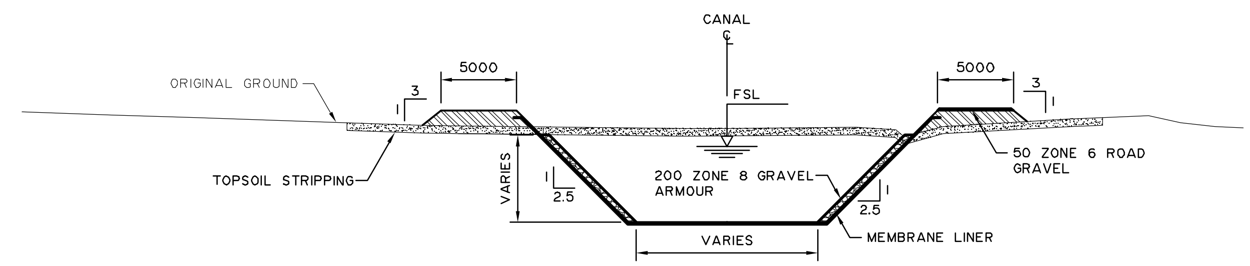
SCENARIO	TOD (m)	FSL (m)
1	725.0	723.0
2	728.0	726.0
3	730.5	728.5

EAST DAM CROSS SECTION (TYPICAL)

SCENARIO	TOD (m)	FSL (m)
1	725.0	723.0
2	728.0	726.0
3	730.5	728.5



WEST DAM CROSS SECTION (TYPICAL)



TYPICAL LINED CANAL CROSS SECTION

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IRRIGATION DEVELOPMENT STUDY
DAM CROSS SECTION AND TYPICAL
LINED CANAL CROSS SECTION

SCALE: N.T.S.	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE 7-4

8.0 ENVIRONMENTAL AND HISTORICAL IMPACTS

8.1 General

Three reports have been generated as part of this study to review the potential impacts that the proposed development may have on the environmental and historical resources in the study area. This section provides a brief summary of the reports. Refer to the following appendices for further information:

Report	**Location**
Water Quality Overview	Appendix F
Overview of Ecological Issues	Appendix G
Historical Resources Overview	Appendix H

8.2 Water Quality Overview

Existing studies and background data were reviewed to determine the water quality characteristics of the Red Deer River and Kennedy Creek, to determine the suitability for irrigation, livestock watering and recreation and to evaluate the potential deterioration of water quality within the system.

The best water quality database for the Red Deer River was at Bindloss, somewhat downstream of the proposed Acadia withdrawal location. There were no data from Kennedy Creek, so data were compiled from four creeks which flow into the Red Deer River from the north, between Finnegan and Bindloss. Water quality for the Red Deer River and the 'surrogate' Kennedy Creek was generally acceptable for irrigation, livestock watering and recreation.

Deterioration in water quality through the system due to evaporation, surface runoff, erosion of saline soils and interaction with groundwater should not be significant enough to limit water usage for irrigation, livestock watering and recreational uses.

After development, Reservoir A1 will initially experience a trophic surge, but in the larger term should be a relatively productive water body with seasonal algal blooms.

Salts will be increased in the system through evaporation in Reservoir A1 and along the canals as well as through drainage from saline lands; however the salinity increase should be small enough to remain below the irrigation guideline. If higher salinity is experienced, the limitation will depend on the salt sensitivity of the crops irrigated and the soil characteristics of the irrigated fields.

The contribution of local water to the reservoir through surface runoff will contribute nutrients to the reservoir. Similarly, local runoff into the canals may introduce sediment, nutrients, bacteria and pesticides. The volume of local runoff from the watershed should be relatively small and efforts should be made to reduce the impacts on water quality through the use of beneficial management practices on the land, including both livestock and cropping practices to reduce erosion and keep contaminants out of the canal and drainage water.

Recreational use of the reservoirs will be affected by the nutrient / plant community development. Water level fluctuations in Reservoir A1 may affect the development of the shoreline weed population, but algal blooms will likely affect aesthetic sensibilities at some times. If development around the lake is contemplated, beneficial management practices should be employed to establish stable shorelines, reduce erosion and minimize inputs of nutrients, bacteria and pesticides.

8.3 Overview of Ecological Issues

The study area is located entirely within the Dry Mixedgrass Subregion of the Grassland Region of Alberta (AEP 1994). Three Ecodistricts (sub-groupings of Natural Subregions) are found within the study area: the Acadia Valley Plain (282.3 km^2); the Bindloss Plain (52.3 km^2); and, the Oyen Upland (19.0 km^2). AGRASID mapping identified 50 soil-landscape models (SLM) in the Study Area. SLMs provide information on soil subgroup, soil drainage/texture and landform. The study area is comprised of approximately 85% dominant or co-dominant Chernozemic soils, 15% Regosolic soils and less than one percent is waterbody.

Vegetation in the study area has been significantly altered from its native state by historic and current agricultural practices. Approximately 41% of the study area remains in a predominantly native condition. Most of the native lands occur in the central, western and southern portions of the study area. Mixed grassland comprised mainly of Spear grasses (*Stipa* spp.) and Wheat grasses (*Agropyron* spp.) characterize native upland habitats in the study area. Permanent wetlands are very rare in the study area. The richest and most [botanically and structurally] diverse vegetation occurs along active floodplains of the Red Deer River. Rare plant occurrence potential is high in the study area. Twenty-five occurrences of 16 rare plants were reported from a search be conducted by the Alberta Natural Heritage Information Center (Rintoul 2005) for 8 Townships in the vicinity of the study area. Rare plants in the study area are most likely to be found in association with the following habitats:
Dry, eroded valley wall and ravine slopes;
Alkaline flats and blowout features (Solonetzic soils);
Wet meadows;
Sandy soils and especially dunes; and,
Poplar and Manitoba Maple woodland along major river valleys.

As many as 37 rare plant communities have potential to occur in the study area. Rare plant communities have potential to occur in all major habitat types but are particularly prevalent in floodplain (riparian) landforms, wetlands, and dunes/blowouts.

A total of 40 vertebrate Species at Risk have potential to occur within the boundaries of the Study Area. These include 24 birds, 7 mammals, 5 reptiles and 4 amphibians. Alberta government records indicate the known occurrence of many Species at Risk within and adjacent to the study area: Burrowing Owl, Ferruginous Hawk, Loggerhead Shrike, Northern Leopard Frog, Western Hognose Snake, Plains Spadefoot, Canadian Toad, Plains Garter Snake, Prairie

Rattlesnake, Bullsnake, Long-billed Curlew, Swainson's Hawk, Short-eared Owl and Ord's Kangaroo Rat.

Sport fish that occur in the lower Red Deer River system include northern pike (Esox lucius), walleye (Sander vitreus), sauger (Stizostedion canadense), mooneye (Hiodon tergisus), lake whitefish (Coregonus clupeaformis), yellow perch (Perca flavescens), burbot (Lota lota), lake sturgeon (Acipenser fulvescens), mountain whitefish (Prosopium williamsoni), goldeye and quillback (Carpiodes cyprinus). Goldeye are considered the most numerous sport fish. During the late 90's to the present, angler creels have revealed a broader distribution of game fish throughout this system than recorded in previous years. In addition, sauger numbers have increased within the angler harvest. Less is known about the presence and distribution of game fish in the very remote lower reaches of the Red Deer River between Hwy 36 and the Saskatchewan border.

Environmentally Significant Areas (ESAs) in the M.D. of Acadia include a variety of upland, wetland and river valley sites, some of which are of provincial or national significance. Three ESAs occur within the boundaries of the study area: 1) Red Deer River – Bindloss/Empress Terraces; 2) Dune Point Springs; and, 3) Red Deer River – Alkali Creek/Dune Point. (Refer to Figure 8-1).

Rare landforms in the study area include: water basins, high relief hummocky terrain, meander floodplain, and confined (terraced) floodplain. These rare landforms occupy approximately 3.7% of the study area. It appears that the current project description avoids all of these landforms. No additional follow-up is required.

Riparian topography in the study area is limited to meander floodplains, and low-relief confined floodplains. Typical vegetation is willow shrubland, which occurs in areas such as Kennedy's Coulee and along the Red Deer River. Wildlife diversity and abundance is high in these limited areas of riparian habitat. The majority of the proposed development appears to avoid riparian areas. One notable exception is the water pipeline from the Red Deer River to Reservoir 1A. This pipeline has potential to affect riparian vegetation in the meander floodplain of the Red Deer River. It is recommended that a major focus of wildlife and species at risk inventory and assessment for this project occur in the area of the pipeline affecting the Red Deer River. Any other smaller scale riparian areas affected by linear features should receive additional inventory focus.

Potential effects on fish from the proposed development include water withdrawals for irrigation and potential for erosion from pipeline construction on the Bow River floodplain. The latter effect can be mitigated through timing restrictions. In terms of effects of water withdrawals, we recommend working closely with Alberta Fish and Wildlife and the Alberta Conservation Association to determine current water volume status with respect to fisheries requirements.

Permanent wetlands are a very scarce resource in the study area. It is beyond the scope of this study to inventory and map seasonal/intermittent wetlands. We recommend that during more detailed planning phases of this study, wetlands be identified and mapped in a 200 to 300-m corridor surrounding the proposed pipeline alignments, and within irrigation blocks. In spite of their rarity, wetlands offer unique and productive habitat for wildlife including some species at risk. Impacts to wetlands, including seasonal varieties, should be avoided.

All major native habitat types in the study area have potential to support federally and provincially listed Species at Risk (SAR). Important habitats for SAR include: floodplains/riparian woodland and shrubland; seasonal wetlands; lightly grazed native grasslands; dunes/blowouts; and, steep, eroded channel banks. The aspects of the development with greatest potential for impacts on SAR are flooding of Reservoir A1, which is located in a predominantly native valley wall/confined floodplain landform; and the water pipeline from the Red Deer River to Reservoir A1. The latter is also located through primarily native habitat in an area of particularly high wildlife and habitat diversity. It is recommended that Species at Risk field surveys be conducted with particular focus on the two areas mentioned above.

The study area has high potential to support rare plants and rare plant communities. The aspects of the development with greatest potential for impacts on rare botanical features are flooding of Reservoir A1 and the supply pipeline from the Red Deer River to Reservoir A1. Both of these areas are located in predominantly native habitat. It is recommended that rare plant and plant community surveys be conducted prior to development with particular focus on the two area mentioned above.

Featured wildlife species in the study area include mule deer, white-tailed deer and antelope. The most important habitat for these species is the valley floodplain of the Red Deer River. Construction should be avoided during the birthing and rearing season for these species (i.e. May and June). Ground surveys for antelope should be conducted as part of Species at Risk inventory and assessment – both in the Red Deer River valley and the Reservoir 1A area.

The two ESAs with greatest potential to be affected by the proposed development are: Red Deer River – Bindloss/Empress Creek; and, Dune Point Springs. The water pipeline from the Red Deer River floodplain to Reservoir A1 transects both of these ESAs. The Red Deer River – Bindloss/Empress Creek ESA is Nationally significant owing to unique habitats that include Plains cottonwood woodland; dense riparian shrubland; dune landforms; and, complex river terrace geomorphology. All of these land features are conducive to the occurrence of vertebrate Species at Risk, rare plants and rare plant communities.

8.4 Historical Resources Overview

The study area for this project is associated with a variety of landforms along with both disturbed and undisturbed terrains. All or most of the lands under consideration for irrigation are presently cultivated. The canals and pipelines will largely be associated with agricultural lands that are disturbed and as such are of limited concern.

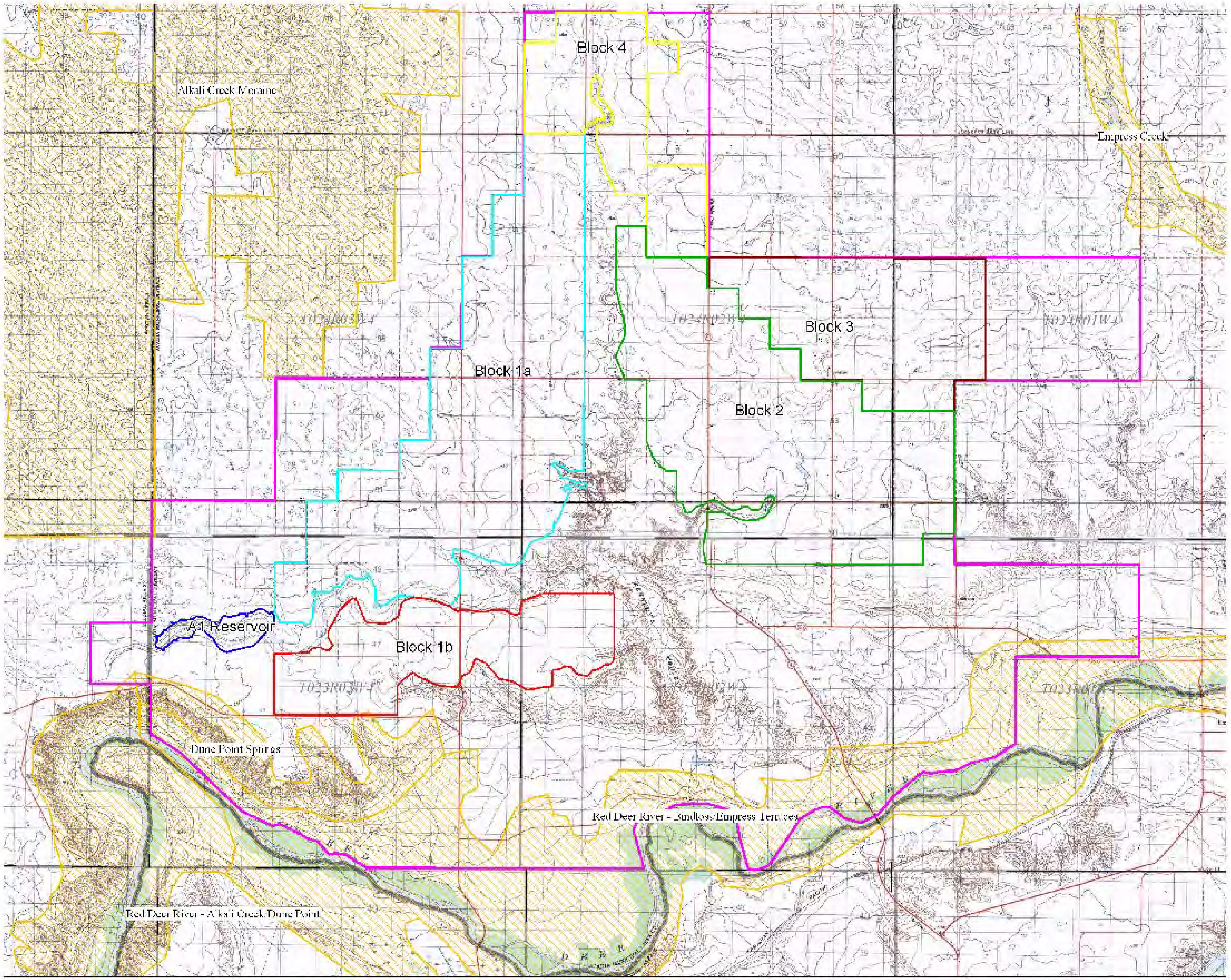
The archaeological potential of the undisturbed areas is very high while the palaeontological potential is highest along the Red Deer River, Kennedy's Coulee and the unnamed tributary that is proposed as the Reservoir A1 site. This tributary is a minor meltwater channel. The potential exists for buried resources within the unnamed tributary along the Red Deer River and at the proposed siphon crossing of Kennedy's Coulee.

Figure 8-2 identifies historically significant sites within the study area. Many sites are close to the proposed projects but of particular concern are those close to the intake on the Red Deer, those associated with the proposed reservoir and those close to the siphon on Kennedy's Coulee. It is these areas that have the greatest potential to impact previously undisturbed cultural resources.

EfOo 93 and 116 (both stone cairns) (Figure 8-2) appear to be close to the proposed intake. EfOo 54 to 57, 94 and 95 are along the upper edges of the unnamed tributary and adjacent to the proposed reservoir. These sites are also all stone features including stone circles, cairns and stone alignment. EgOn 14 is a stone circle site along Kennedy's Coulee in the vicinity of the proposed siphon.

A Historical Resources Impact Assessment is recommended for this project. This work is recommended for undisturbed areas including the intake, intake pipeline, reservoir, and the distribution canals and pipelines. Deep testing is recommended for this project with a particular focus on depositional areas including but not limited to the water intake on the Red Deer River, the proposed reservoir and the siphon crossing of Kennedy's Coulee. Portions of the project are associated with sections with paleontological notations and paleontology will also require consideration.

Refer to Appendix H for further information.



ENVIRONMENTALLY SIGNIFICANT AREAS

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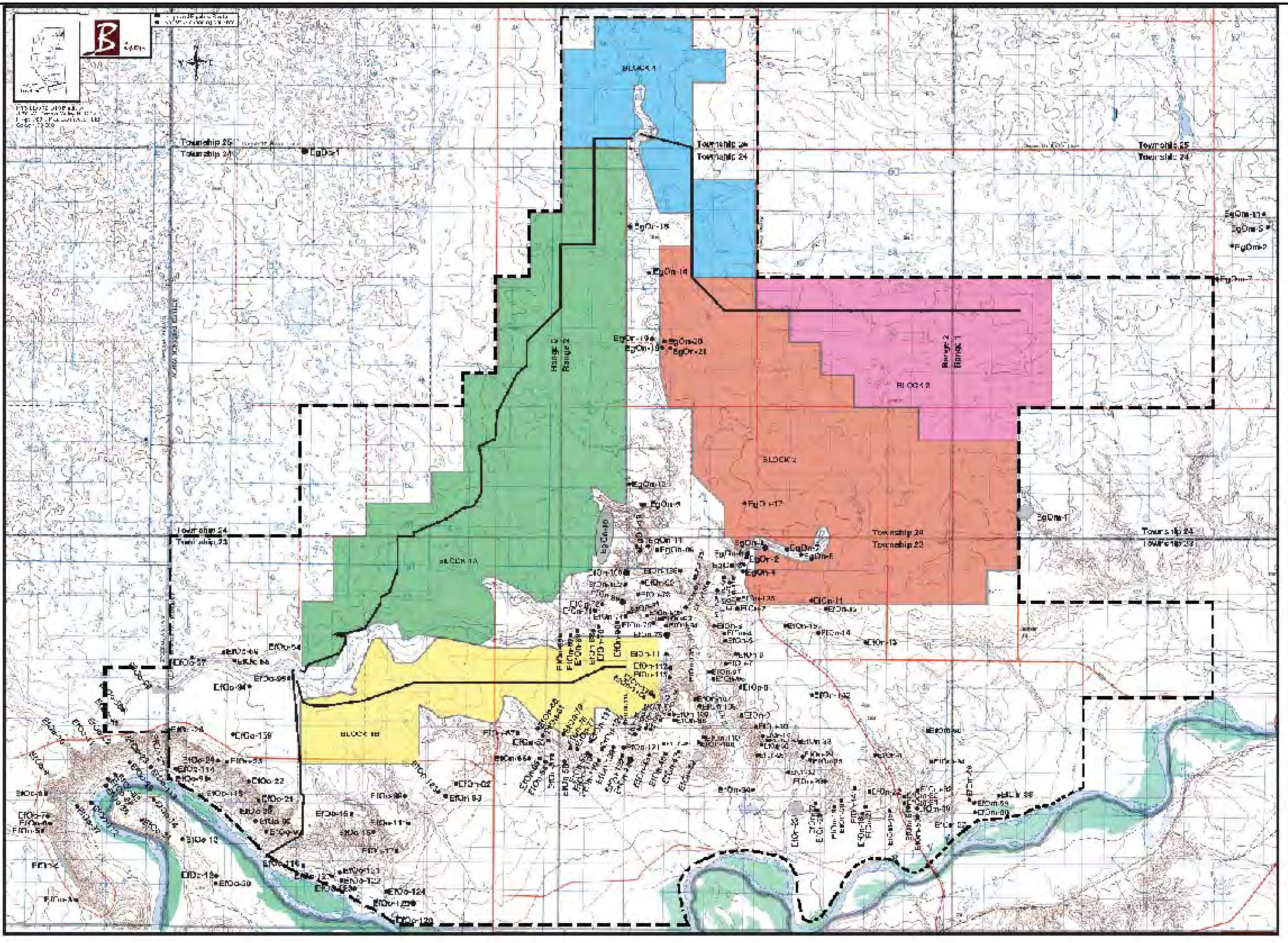
M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY
ENVIRONMENTALLY SIGNIFICANT AREAS

SCALE: 1: 100,000	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 8-1



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M.D. OF ACADIA No.34

IRRIGATION DEVELOPMENT STUDY

HISTORICALLY SIGNIFICANT AREAS

SCALE: N.T.S.	DATE: APRIL 2005	JOB: 2280-001-00	FIGURE: 8-2

9.0 PROJECT COSTS

9.1 General

This section provides a summary of the capital, as well as operation and maintenance (O&M) costs that were determined for the three development scenarios. The costs in this section address the irrigation system infrastructure and O&M costs. Detailed cost tables and additional information is provided in Appendix I. On-farm cost information is addressed in the economics analysis discussed in Section 10 and Appendix A.

9.2 Assumptions and Criteria

The following summarizes the basic assumptions and criteria used for the capital cost and O&M estimates for this study:

1) Cost estimates have been developed based on a number of evaluations. These include comparisons with existing pump stations for large-scale irrigation systems, such as the existing Deadfish pump station on the Red Deer River developed and operated by Alberta Environment. Costs for the distribution systems have been based on current costs from the irrigation industry. Earthworks costs for the dams and canals have been based on comparisons to recent dam and irrigation construction projects.

2) All cost estimates are in 2004 dollars. No specific adjustments or allowances have been made to account for short-term cost fluctuations in the construction industry. For example, there have been wide fluctuations in the price of steel over the last year due to increased world-wide demand for steel. The price of PVC pipe has also been subject to price increases beyond normal increases in the consumer price index, due to the impact of the volatile price of crude oil. Another area of potentially very significant cost impact involves the current (spring 2005) anticipation of large increases in construction costs for all types of construction, due to the large influx of federal, provincial and municipal infrastructure funding. This large project load is creating shortages in labour and equipment resources and results in higher pricing. This is expected to have a serious impact for at least a few years.

3) The cost of electrical energy is a very large component of the annual operation and maintenance costs for the irrigation development (±63%). The de-regulation of the electrical industry has caused, at least in the short-term, turmoil and rapidly changing supply and distribution conditions. Since energy supply has become a very competitive business, it is difficult to obtain estimates or quotes for a future project. The study's cost analysis is based on the electrical energy cost of **$0.075/kWh**, as advised by a representative of an electrical distribution company. This figure is considered reasonably conservative. The electrical supply costs proposed for this study have been compared to energy costs for Alberta Environment's Deadfish pump station in 2004. After adjusting for the difference in elevation lift, the cost per pumped m^3 is quite comparable.

4) On-farm operational costs used in the economic analysis (Section 10) include energy costs for either electrical or natural gas supply. These costs are based on estimates from the local utility companies (ATCO Electric and Dry Country Gas Co-op Ltd).

9.3 Capital Infrastructure Costs

Capital cost estimates have been developed for the various components for each of the three development scenarios. The cost estimates are developed on the basis of comparisons to other works of similar scope and nature.

9.3.1 Diversion and Supply System

The diversion works consist of the river intake, the main pump station and the supply pipeline to the reservoir.

The costs for the diversion works include allowances for fish-screening facilities. Fish screening can be accomplished by a number of different methods.

The main pump house conceptual design is roughly based on the layout of the Deadfish Diversion pump house. Costs are based on unit costs for the excavation and cast-in-place concrete for the wet well. The costs of the high lift vertical turbine pumps are based on the budget estimate from suppliers. Electrical switch gear, motor starters etc. has also been based on order-of-magnitude budget estimates from suppliers. Building costs are based on unit rates from recent comparable building projects.

The cost of the electrical power grid upgrade and new sub-station has been included based on the estimate from ATCO Electric, which holds the franchise agreement for the “wires” part of the electrical supply for the study area.

Diversion works costs also include provisions for cofferdam installation during construction of the facilities, as well as permanent erosion protection on a section of the north river bank for purposes of “training” the river and protecting the intake works.

The cost of the supply pipeline has been estimated from unit rates for main steel pipeline construction.

The total capital costs of the diversion works are summarized in Table 9.1, excluding contingencies, engineering and other site investigations.

Table 9.1
Diversion and Supply System Costs

Diversion and Supply	Scenario 1	Scenario 2	Scenario 3
Capital Cost Estimate:	$12.02 million	$16.63 million	$16.63 million

9.3.2 Storage (Reservoir A1)

The storage Reservoir A1 includes the construction of two dams: the main (east) dam and the smaller (west) dam on a tributary to Kennedy Coulee. Two outlet structures are provided in the main dam (to supply Secondary A canal and Secondary B pipeline) and a small pump vault in the west dam.

The cost of the dams has been established from the individual quantities as determined by computer terrain modeling (Autodesk Land Development 2004), and the conceptual design for the various additional elements such as filter drains, access road and slope erosion protection. The unit rates for the earthworks materials have been developed from tendered prices for recent earthworks projects such as dam rehabilitation, reservoirs and canal works.

The storage facilities also include costs for the two outlet structures. Costs for control gates have been estimated based on budget quotes from a gate supplier.

The total capital costs of the water storage works are summarized in Table 9.2, excluding contingencies, engineering and other site investigations.

Table 9.2
Storage Costs

Storage (Reservoir A1)	Scenario 1	Scenario 2	Scenario 3
Capital Cost Estimate:	$10.83 million	$12.75 million	$12.75 million

9.3.3 Distribution System

The distribution system involves all infrastructure downstream of Reservoir A1, to the farm turn-outs. This includes all main canals and pipelines, pipeline laterals, all in-line structures and turn-outs, and the pump station at Acadia Reservoir.

The capital costs for the main distribution system as well as for the distribution laterals have been developed from unit costs per kilometer. These unit costs are detailed in the cost tables in Appendix I. The distribution system also includes costs for the acquisition of easements.

Easement costs are averaged at $1000/ha (based on land cost of $300 per acre plus $100 per acre for legal surveys, and the average easement width at 40m).

The secondary pump house estimate (Acadia Reservoir), includes unit costs for the cast-in-place concrete wet well. The costs of the vertical turbine pumps are based on budget estimates from suppliers. Electrical switch gear, motor starters etc. has also been based on order-of-magnitude budget estimates from suppliers. Building costs are based on unit rates from recent comparable building projects.

The total capital costs of the distribution works are summarized in Table 9.3, excluding contingencies, engineering and other site investigations.

Table 9.3
Distribution System Costs

Distribution System	Scenario 1	Scenario 2	Scenario 3
Capital Cost Estimate:	$15.12 million	$27.12 million	$37.20 million

9.3.4 Capital Cost Summary

The capital costs for each component of the three development scenarios are summarized in Table 9.4. The overall capital cost varies from $55M for Scenario 1 to $96M for Scenario 3. The unit cost varied from $8,857 to $9,927/ha ($3,584 to $4,017/acre), with Scenarios 2 and 3 being the lowest at approximately the same cost/irrigated hectare.

Table 9.4
Capital Cost Estimate Summary

Description	Scenario 1	Scenario 2	Scenario 3
Diversion and Supply System:			
River Intake and High Lift Pump Station	$5,650,000	$9,590,000	$9,590,000
Power Supply (incl. sub-station)	included	included	included
Supply Pipeline to Reservoir	$6,370,000	$7,040,000	$7,040,000
Storage Reservoir (A1):			
East Dam	$7,770,000	$8,800,000	$9,890,000
West Dam	$830,000	$990,000	$1,320,000
Outlet Structures and Miscellaneous	$2,230,000	$2,960,000	$3,610,000
Distribution System:			
Secondary A Canal (Reservoir A1 to Siphon)	$7,400,000	$8,770,000	$8,930,000
Siphon (Across Kennedy Coulee)	$0	$2,090,000	$2,090,000
Secondary A Canal (Siphon to Acadia Resv.)	$1,390,000	$1,390,000	$2,010,000
Secondary A Canal (East of Kennedy Coulee)	$0	$7,600,000	$7,600,000
Secondary B Pipeline	$2,700,000	$2,700,000	$2,700,000
Secondary C Pressure Pipeline	$0	$0	$8,250,000
Block 4 Pressure Pipeline	$1,910,000	$1,910,000	$1,910,000
Acadia Reservoir Pumphouse	$500,000	$500,000	$1,000,000
Miscellaneous (mobilization, automation etc)	$1,220,000	$2,160,000	$2,710,000
Other:			
Contingencies (25%)	$9,490,000	$14,130,000	$17,160,000
Engineering Design, Geotechnical and other Site investigations	$7,120,000	$8,480,000	$10,300,000
TOTAL CAPITAL SYSTEM COST	**$54,600,000**	**$79,100,000**	**$96,100,000**
Total Irrigated Area: (ha)	5500	8900	10850
Capital Cost per irrigated hectare	$9,927	$8,888	$8,857
Capital Cost per irrigated acre	$4,017	$3,597	$3,584

9.4 Operation and Maintenance Costs

The operation and maintenance costs for the works have been estimated as a percentage of the total capital costs for the diversion works and storage reservoir, and a cost per acre for the distribution system. These are summarized in Table 9.5.

Table 9.5
O & M – Basis of Costs

Description	Annual Operation and Maintenance Costs
Main Pump Station	2.5 % of capital costs
Supply Pipeline	0.25 % of capital costs
Reservoir	0.5 % of capital costs
Acadia Secondary Pump Station	2.5 % of capital costs
Distribution System	$15.00 per acre

The O & M cost values identified in Table 9.5 were determined from review of values used for similar large scale irrigation projects and actual annual costs experienced by irrigation districts. The annual O & M cost of $15/acre for the distribution system includes all maintenance and operation to operate the system. This value is near the upper end of the 2004 rates charged by existing four irrigation districts.

The energy costs for the operation of the pump stations were based on estimates from ATCO Electric. These costs include fixed annual charges for the electrical sub-stations as well as energy charges. The fixed (standby) charges reflect in essence the amortization of the user-component of the capital investment that the electrical distribution company contributes for the sub-station. The total energy costs in this study are based on a conservative estimate of $0.075/kWh. Since the de-regulation of the electrical industry, various electrical energy retail providers have entered the market. The cost per kWh is now distinctly split with components for the distribution (the "wires") of the system as well as the retailing (the "energy"), plus a plethora of rate riders and administration costs. The energy retail market is now more competitive than before de-regulation, but also more difficult to estimate for a project such as the Acadia Irrigation Development. This project requires a very substantial upgrade to the power grid (including a new electrical sub-station for the River Pump Station), and the power demand during the operational season is high, but drops to near zero in the off-season.

The total annual Operation and Maintenance costs for the three development scenarios are summarized in Table 9.6. A detailed breakdown is provided in Appendix I.

Table 9.6
Total Annual O & M Costs

Total O & M	Scenario 1	Scenario 2	Scenario 3
Annual Cost	$1,650,000	$2,430,000	$2,860,000

9.5 Irrigation Rate Structure

Most existing Irrigation Districts within the Province are served through a provincially owned and operated Headworks system. The definition of what would be included as Provincially Owned Headworks for the Acadia Development is unknown; as is the contribution towards energy charges and other O & M of the Headworks which irrigators would be expected to pay. The Deadfish/Sheerness Irrigation System is similar to the Acadia Development. This project is an example of where the Headworks include the River Pump Station, supply pipeline and canals and storage reservoir, and are owned and operated (including energy costs) by Alberta Environment. Irrigators pay an irrigation rate equivalent to the highest annual rate charged by other Irrigation Districts in Alberta. For purposes of this study, it is assumed that the Headworks would include:

- River Pumpstation
- Supply Pipeline
- Reservoir A1.

It is important to point out that the irrigation rate structures reviewed in this section include only operation and maintenance costs, and that amortization of capital cost components has not been accounted for.

It is assumed that most of the energy costs for the operation of the secondary pump station on the Acadia Recreational Reservoir are recovered from those irrigation services directly benefiting from the pressure delivery (Blocks 3 and 4). These pressure surcharges have been assumed at $30.00 per irrigated acre (all scenarios) in the applicable Blocks and would be added to the main irrigation rate for the farmers that are benefiting.

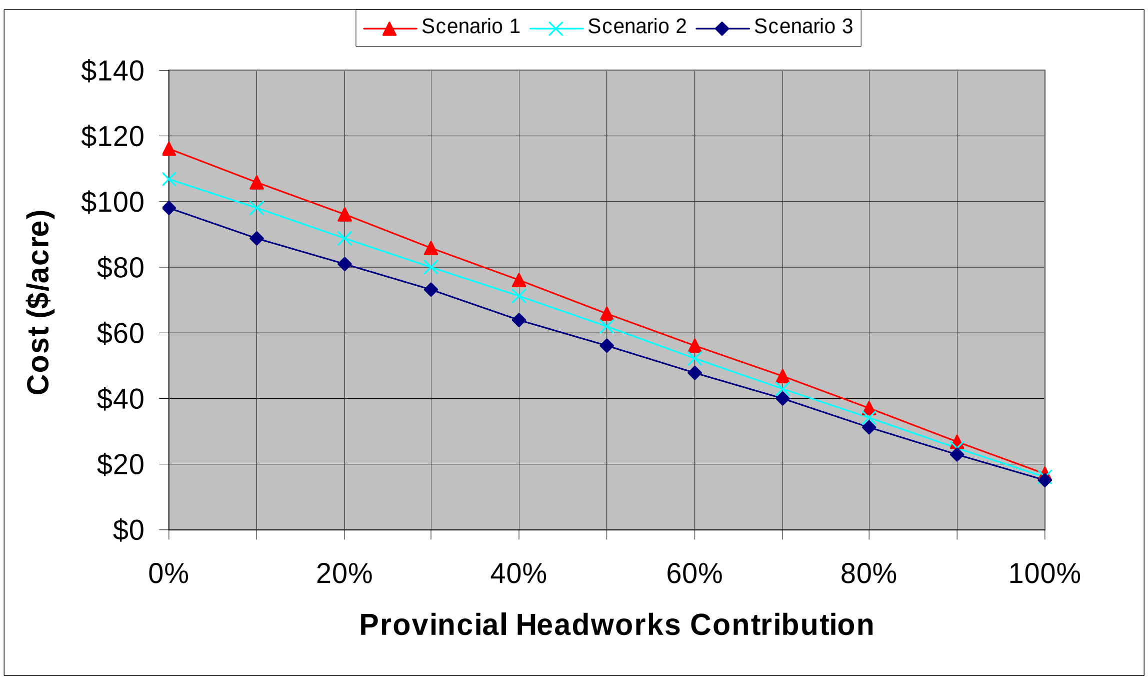
The Provincial contribution towards the Headworks O & M (including energy costs) is not known at this time; therefore, a range of irrigation rate structures were developed for varying levels of Provincial contribution as shown on Table 9.7, and illustrated on Chart 9A. Rates based on 0%, 75% and 100% Provincial contribution towards the Headworks O & M were used in the on-farm economic analysis in Section 10.2.

Table 9.7
Irrigation Rate Structure

Provincial Contribution Level to Headworks O&M	Rate Required to Cover Off-Farm Irrigation O & M (cost/acre)*		
	Scenario 1	Scenario 2	Scenario 3
0%	$116	$107	$98
10%	$106	$98	$89
20%	$96	$89	$81
30%	$86	$80	$73
40%	$76	$71	$64
50%	$66	$62	$56
60%	$56	$52	$48
70%	$47	$43	$40
80%	$37	$34	$31
90%	$27	$25	$23
100%	$17	$16	$15

* Rates are rounded to nearest dollar per acre.

Chart 9A
Irrigation Rate Structure



Notes: 1) Provincial headworks contribution includes annual headworks O&M and all river diversion pumping costs.
2) These costs do not include the sur-charge of $30.00/acre for the parcels in Blocks 3 and 4.

10.0 ECONOMIC ANALYSIS

10.1 Introduction

This analysis is divided into three parts:

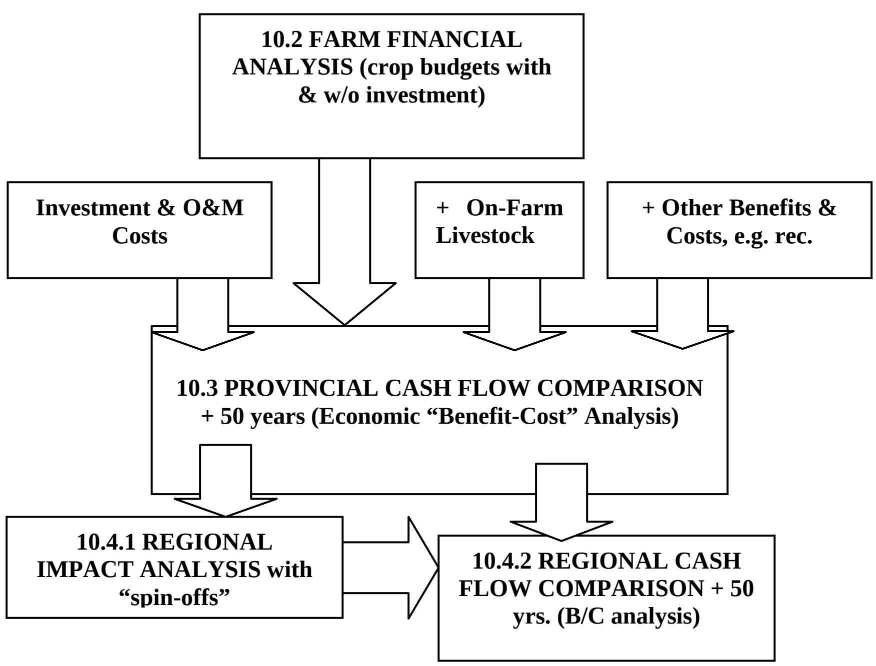
1) Sub-Section 10.2. Farm Financial Analysis: A financial analysis of what irrigation would mean to existing dryland farmers in the project area in M.D. of Acadia #34. This analysis focuses on capacity-to-pay, production and profitability, as well as required structural changes.

2) Sub-Section 3. Provincial Benefit-Cost Analysis: An economic cash flow analysis comparing the incremental real direct benefits over time to the incremental real direct costs over time. This analysis employs a provincial accounting stance; not a regional perspective.

3) Sub-Section 4. Regional Impact Analysis: An analysis of how irrigation development would impact the Acadia Valley region, both in the short-term and in the long term. The focus of this analysis is on income and employment growth in the project area. In this context, a Regional Benefit-Cost comparison is also conducted.

These analytical components are linked to one another so there is a logical and numerical consistency throughout. Sub-Section 10.3 is developed utilizing the data from Sub-Section 10.2; Sub-Section 10.4 is developed utilizing the data from Sub-Section 10.3. Chart 10A illustrates these inter-dependencies:

Chart 10A



10.2 Farm Financial Analysis

The farm financial analysis addresses three specific questions:

1) Irrigated farmers' capacity-to-pay for irrigation system costs.
2) Comparative structural characteristics (capital and labour).
3) Relative profitability (irrigation versus dryland).

This analysis is conducted on a **per-acre basis** and the accounting practices employed are generally consistent with a 1988 AAFRD study entitled **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**.[1]

10.2.1 Irrigated Crop Production

10.2.1.1 Crop Budgets

Crop budgets for irrigated crops are based on:

a) projected cropping patterns with irrigation in Acadia Valley
b) existing secondary cost-of-production data for irrigated crops in southern Alberta
c) projected long-term crop prices; and d) related secondary data on capital-labour characteristics of irrigated farms in southern Alberta.

The net result is a "basket" or irrigated crops which are then weighed by the projected crop mix to generate a composite per-acre "average" revenue and cost estimate for all irrigated crops. This is provided in Appendix A, Table 2.6.

10.2.1.2 Off-Farm Irrigation System Costs

The irrigated crop budgets also need to take into account farmer contribution to off-farm system costs. This contribution (or the irrigation rates farmers pay to have water delivered to their farm) has not been determined yet and will depend on the Provincial contribution to the Headworks O & M, as discussed in Section 9.5. For the basis of this economical analysis, three "hypothetical" rate schedules have been identified:

1) Rate #1 – No Provincial O & M contribution.
2) Rate #2 – 75% Provincial contribution towards Headworks O & M
3) Rate #3 – 100% Provincial contribution towards Headworks O & M.

These rates do not include any contribution to off-farm capital costs. This cost-sharing formula has not been determined yet; therefore, these three hypothetical "rate schedules" were constructed to simulate how different off-farm irrigation system costs would affect the profitability of irrigated agriculture in Acadia Valley, as shown on Table 10.1.

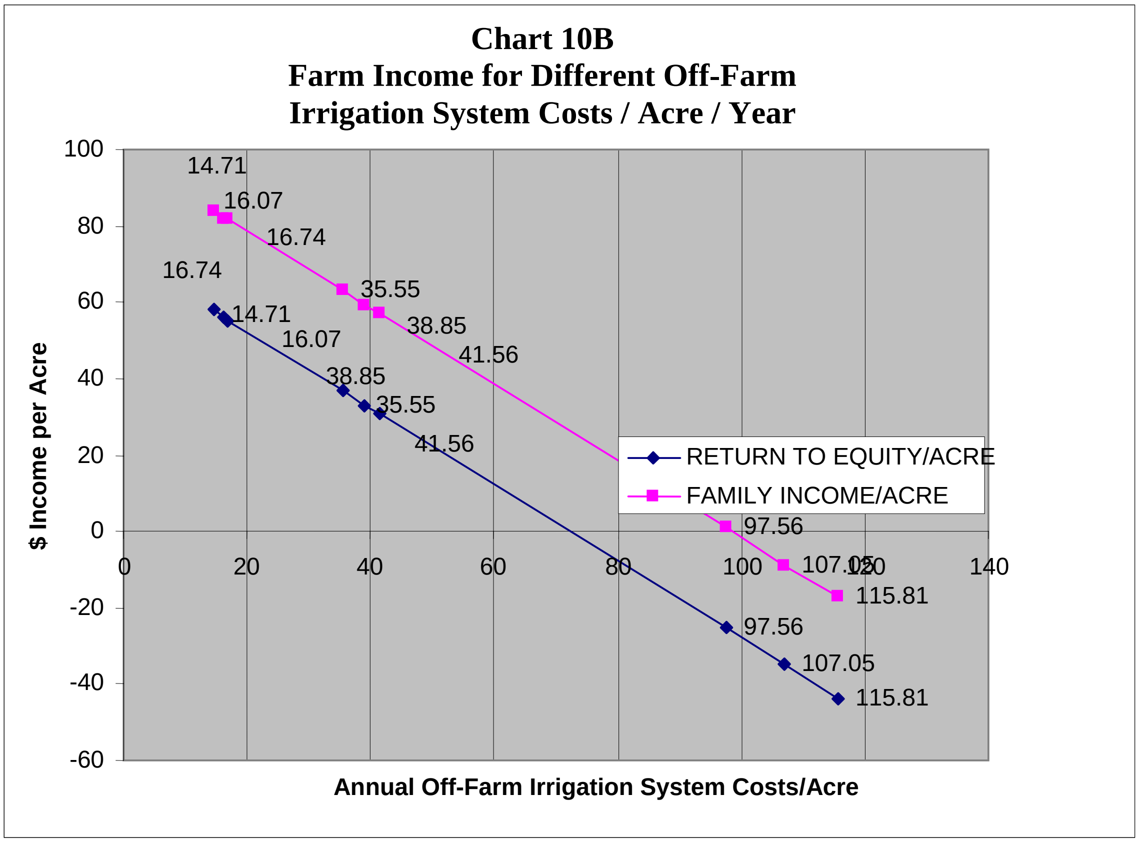
[1] Heikkila, R., **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**, AAFRD, Edmonton, September 1988.

Table 10.1
Hypothetical Rate Schedules

Rate Schedule	Scenario 1	Scenario 2	Scenario 3
#1 @ 0% Provincial Headworks Contribution	$115.81	$107.05	$97.59
#2 @ 75% Provincial Headworks Contribution	$41.56	$38.85	$35.55
#3 @ 100% Provincial Headworks Contribution	$16.74	$16.07	$14.71

10.2.1.3 Profitability

The profitability of irrigation will depend, first and foremost, on how much farmers have to contribute to annual off-farm system O&M. Thus, we have simulated how each of the three hypothetical cost regimes (above) would impact on per-acre profitability as defined by return-to-equity, farm family income, and return to capital (%).[2] The results of these simulations are illustrated in Chart 10B.



[2] Return-to-equity = Revenue less Total Production Costs (=Variable Costs + Fixed Costs + Capital Costs + Unpaid Family Labour Costs). Family Income = Return to Equity + Return to Unpaid Family Labour.

At an annual off-farm O&M cost of say, $15/acre/year (Rate Schedule #3), family income is projected to be about $83/acre/year. At $38/acre/year (Rate Schedule #2), family income would likely drop to about $60/acre/year. And at, say, $100/acre/year (Rate Schedule #1), family income would probably become negative. At the same time, for Rate Schedule #3, #2, and #1 the rate-of-return to capital would likely be about 8 to 9%, 7 to 8%, and, 3 to 4%/annum, respectively.

The local farmers' capacity-to-pay is still unclear because the agronomic, financial and managerial characteristics of each potential irrigation farmer are unique. We are reasonably certain, however, that it would be between $15 and $85/acre/year. Our professional judgment would further suggest that an annual off-farm system cost of about **$50/acre/year would likely be a potential maximum.**[3] At $50/acre/year, the projected annual per-acre return to equity is $22/acre; the projected annual family income per acre is $48/acre; and the return-to-capital is 6.9 percent/annum. [4]

10.2.2 Irrigation Versus Dryland[5]

Two comparisons of the benefits irrigation would provide over dryland farming will be considered:

a) anticipated changes to farm structure.
b) anticipated changes to relative profitability.

The comparison following assumes that off-farm irrigation system costs are $50/acre/year.

10.2.2.1 Structural Characteristics

Irrigation would radically change input use, capital requirements, labour requirements, and overall production levels. Revenues and cash costs would both likely increase about four-fold while total production costs would be expected to increase about 3.3 times. At the same time, with irrigation, capital requirements would probably increase about 7.5 times (and the annual capital costs about 5.4 times) while labour requirements would probably increase about 3.1 times. These comparisons are summarized in Table 10.2.

[3] The rationale for this assessment is provided in Appendix A, Section 2.3.8.
[4] For additional details, see Appendix A, Section 2.3.8.
[5] To make these comparisons, a composite dryland crop budget is also required, as described in detail in Appendix A, Section 2.2. See especially Table 2.3.

Table 10.2
Structural Characteristics Comparison

Variable		Dryland	Irrigation	Ratio Irrig./Dryland
A	Gross Annual Revenue/Acre	$114	$458	4.0
B	Variable Costs/Acre	$86	$293	3.4
C	Fixed Costs/Acre	$4	$9	2.25
D	Capital Costs/Acre	$20	$108	5.4
E	Cash Costs (B+C)	$90	$302	3.4
F	Total Production Costs (B+C+D+I)	$122	$436	3.6
	Capital (excluding land)	$173	$1,293	7.5
	Labour (hired + unpaid)	1.25	3.84	3.1

10.2.2.2 Relative Profitability

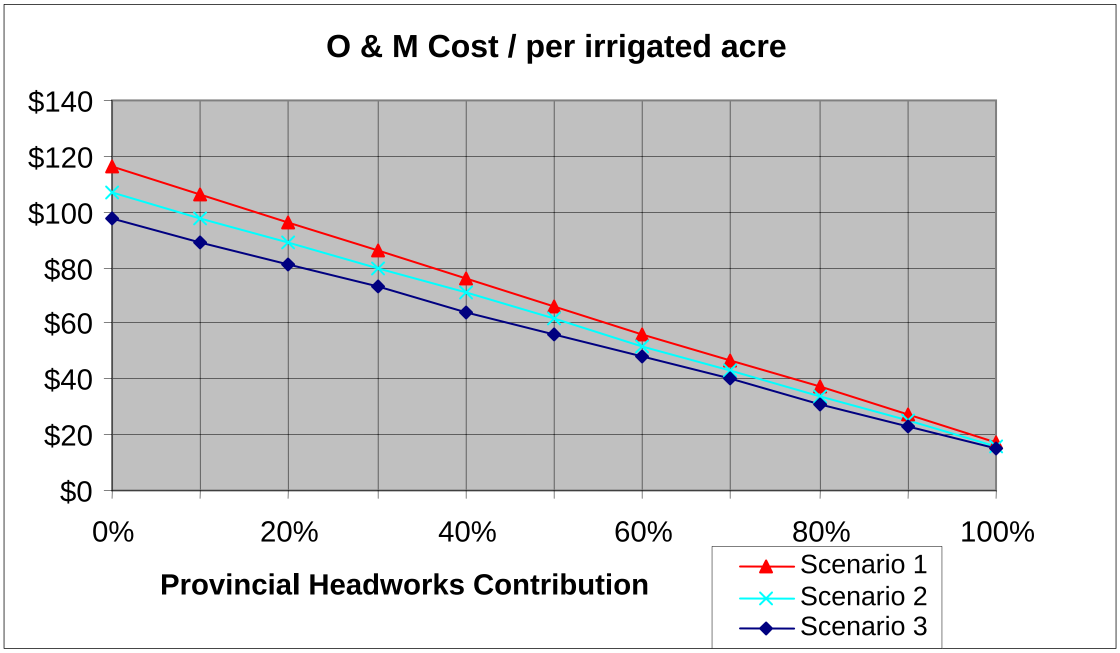
In terms of relatively profitability, revenues and costs per acre would also tend to climb 3 to 4 times while the gross margin would be projected to increase about 6.5 times. The dollar return to capital invested could climb 10.8 times, as well as increase the annual rate-of-return to capital by about 4 percentage points. Perhaps most importantly, average annual profits would be expected to climb from a negative $8 per acre per year to a very positive $22 per acre per year. At the same time, farm family income would be expected to increase from a relatively low $4/acre/year to $48/acre/year. With 1000 acres of dryland, family income is a meager $4,000/year whereas with 1000 acres of irrigation, family income is $48,000/year. These per-acre comparisons are summarized in Table 10.3.

Table 10.3
Relative Profitability Comparison

Measure	Dryland	Irrigation	Ratio Irrig./Dryland
Gross Margin (A-E)	$24	$156	6.5
Return to Investment $	$12	$130	10.8
Return to Investment %	2.6%	6.9%	2.7
Return to Equity (“Profit”)	($8.11)	$22	n/a
Family Income (“Cash Flow”)	$4	$48	12.0

It bears repeating that these comparisons are made assuming that the annual off-farm system cost to farmers is $50/acre/year. If it was higher, these ratios (and, thus, irrigation adoption rates) would drop; if it was lower, these ratios (and, thus, irrigation adoption rates) would be higher.

Additional details are provided in Appendix A, Sub-Section 2.



10.3. Provincial Cash Flow Analysis

10.3.1 Methodology

10.3.1.1 Evaluation Criteria

A provincial discounted cash flow analysis compares quantifiable projected benefits with quantifiable projected costs into the foreseeable future. This "benefit-cost analysis" helps determine if a proposed investment would or would not use Alberta resources efficiently.

In this context, four criteria are utilized to gauge how (socially) profitable a proposed investment would be:

CRITERIA	DESCRIPTION
1. Internal Rate of Return (IRR)	That interest (i.e. discount) rate where the cumulative discounted benefits are exactly equal to the cumulative discounted costs over a given time period. Preferred by many (e.g. World Bank) because it avoids pre-determining what the most appropriate social discount (i.e. interest) rate should be. However, politically, this still requires establishing a minimum acceptable rate of return.
2. Benefit-Cost Ratio (B/C Ratio)	The ratio of cumulative discounted benefits to cumulative discounted costs over a given time period for a particular interest rate. Different methodologies can generate different ratios <> unity. No units. Measures efficiency ("bang for the buck") but not scale.
3. Net Present Value (NPV) of Incremental Socio-Economic Benefits	Cumulative discounted benefits minus cumulative discounted costs over a given time period for a particular interest rate. Measures the incremental cumulative absolute dollar value over time. Probably the best economic measure when selecting between Investment A and Investment B if both opportunities have a B/C ratio > 1.
4. Pay-back Period	The number of years required to recover the capital and on-going discounted cost of a proposed investment.

To be considered economically feasible from a provincial perspective, the Internal Rate of Return (IRR) must exceed a politically prescribed minimum annual rate-of-return. At the same time, for a specified interest (or discount) rate the Benefit/Cost (B/C) ratio must be greater than one, the Net Present Value (NPV) must be positive, and the pay-back period should not exceed a maximum number of years approximated by 70/interest rate (e.g. at 4% ⇒ 18 years).

These are all efficiency criteria which entirely ignore equity considerations**.** These criteria also ignore who actually pays or who actually benefits. The rationale for this is that if NPV>0 and B/C>1 for the province, then it should always be possible for those who gain from the implementation of a particular investment to compensate those who lose (if, indeed, there are losers) from project implementation. At the same time, this simple calculus also fails to consider (without further refinements) the possibility that a dollar may be worth more to a relatively poor community than to a relatively wealthy community.

10.3.1.2 Methodological Procedures

a) Standards & Precedents

There are well-established and widely-used standards and procedures for conducting a cash flow analysis of potential investment opportunities. The methodology employed in this analysis is generally consistent with that of the World Bank, as well as what has been utilized in three other recent water management studies in Alberta:

1) Klohn Crippen, **Milk River Basin Preliminary Feasibility Study**, Alberta Environment, February 2004.
2) Golder, **Meridian Dam Preliminary Feasibility Study,** Alberta Environment, February 2002.
3) Alberta Environment, **Proposed Little Bow Project/Highwood Diversion Plan, Environmental Impact Assessment, Vols. 4 (Socio-Economic Assessment) and 9, appendix P (Economic and Socio-Economic Assessment)**, Edmonton, 1995.

b) Procedures

Methodological procedures include:

1) Time frame: Construction period plus 50 years = 53 years
2) Costs and prices: Constant 2004-05 dollars for a 53 year period
3) Social Discount Rate: Uncertain, but probably ranges from 2% to 4% per annum (net of inflation)
4) Economic Prices: Adjustments to account for non-market financial price distortions (called “shadow pricing”) limited to eliminating existing subsidies to AFSC dryland crop insurance premiums
5) Scheduling: Irrigation assumed to begin after construction at a rate of 3300 acres per annum until full development with all annual costs and revenues being linked to this development schedule.

Additional details can be found in Appendix A, Section 3.1.2.

10.3.2 Cash Flow Analysis

Utilizing the above methodological framework, a discounted cash flow analysis was then conducted for each of the three development proposals:

1) Scenario 1: 5,500 ha. (13,600 acres)
2) Scenario 2: 8,900 ha. (22,000 acres)
3) Scenario 3: 10,850 ha. (27,000 acres)

For each Scenario, the quantified incremental costs and benefits are:

INCREMENTAL COSTS	INCREMENTAL BENEFITS
1. Construction Costs & O&M	1. Annual Δ Crop Revenue
2. On-Farm Irrigation Equipment Costs	2. Annual Δ Livestock Revenue
3. On-Farm Supplementary Equip. Costs	3. Other Incremental Benefits (livestock water, domestic water, recreation)
4. Annual Δ Crop Production Costs	
5. Annual Δ Livestock Production Costs	

Total estimated capital costs (over three years) are $54.6M, $79.1M, and $96.1M for Scenarios 1, 2, and 3, respectively. The corresponding O&M costs, at project maturity, are estimated to be $1.65M, $2.43M, and $2.86M per year. (For further details, see Appendix A).

On-farm irrigation equipment costs are expected to average $818/acre with a 25 year life span; supplementary equipment costs about $302/acre with a 20 year life span. Incremental per-acre costs of production for crops and livestock are estimated to be about $149/acre and $137/acre, respectively. All farm-related costs are linked to projected irrigation development rates.

With respect to projected incremental revenues, the incremental per-acre revenue estimates for crops and livestock are $344/acre and $183/acre, respectively. These revenue streams are also linked to projected irrigation development rates. Other relatively minor incremental benefits are expected to arise from improved access to livestock water ($5 per acre/year) and enhanced recreational amenities (initially about $3/acre/year).

Table 10.4 summarizes the results of these cash flow simulations.

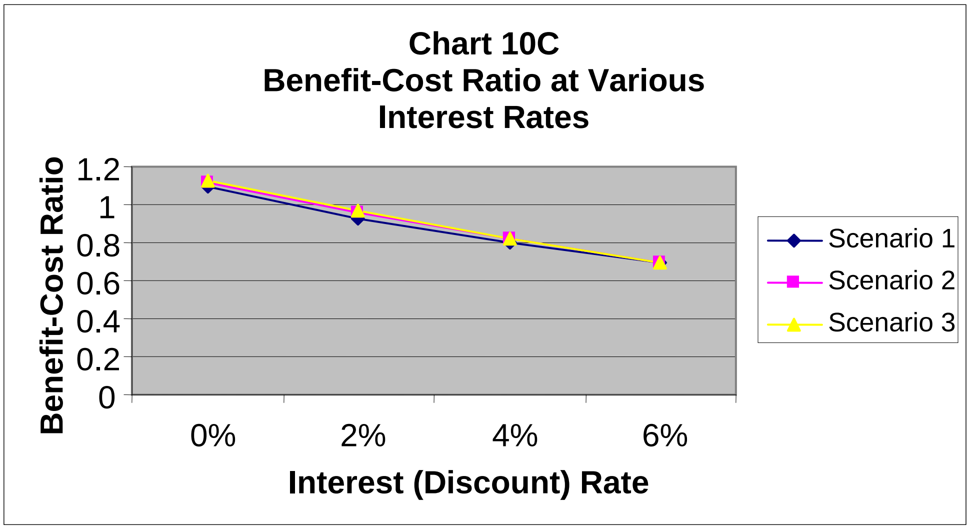
Table 10.4
Summary of Provincial Cash Flow Analysis

Criteria	Scenario 1	Scenario 2	Scenario 3
IRR	**1.14%**	**1.46%**	**1.59%**
B/C Ratio:			
0%	1.09	1.12	1.13
2%	0.93	0.96	0.97
4%	0.80	0.82	0.82
6%	0.69	0.70	0.70
NPV: ($M)			
0%	30.1	58.8	78.3
2%	-14.4	-13.6	-12.8
4%	-32.4	-43.4	-50.4
6%	-39.9	-56.0	-66.4

Source: Appendix A, Tables 3.9, 3.10, and 3.11.

The Internal Rate of Return (IRR) is estimated to range from 1.14%/year to 1.59%/year for Scenarios 1, 2, and 3, respectively. The rates-of-return for Scenarios 2 and 3 are fairly similar, although Scenario 3 does look slightly better. In today's financial markets, the GOA might also consider the projected real rates-of-return (net of inflation) for Scenarios 2 and 3 as "acceptable".

Estimated Benefit-Cost ratios are consistent with the corresponding IRR's. For Scenarios 2 and 3, the B/C ratio will exceed unity for any discount rate less than about 1.5% per annum while it will be less than unity for any discount rate in excess of about 1.5% per annum. (Chart 10C).



Similarly, for Scenarios 2 and 3 we would expect a negative NPV if the discount rate was more than about 1.5% per annum; and a positive NPV if the discount rate was less than about 1.5% per annum.

10.3.3 Sensitivity Analysis

Sensitivity tests were conducted on six variables.

1) adjustment for regional income disparities
2) real agricultural prices
3) real agricultural costs-of-production
4) real project capital cost changes
5) real operating and maintenance cost changes
6) impact of water deficiencies.

This analysis indicates that for Scenario 3 (the economically "best" case), the confidence band which brackets the internal rate of return (IRR) of 1.59 could be as low as 1.0% and as high as 4.1 percent. Similarly, the confidence band which brackets the B/C ratio of 0.82 (for an interest rate of 4%/annum) could be a low as 0.67 and as high as 1.01.

This provincial cash-flow projection is particularly important as a means of systematically and comprehensively looking at all the socio-economic variables on one spreadsheet. All of these considerations are documented in great detail in Appendix A, Sub-Section 3. Many other inputs, of course, are also required in the decision-making process.

10.4 Regional Impact Analysis

10.4.1 Regional Impact Calculations

The regional impact of project implementation on four main economic variables is considered important:

- Sales and direct expenditures.
- Gross domestic product (GDP or value-added).
- Employment.
- Income.

To approximate regional impacts, the methodology employed utilizes four data sets:

- Estimated incremental expenditures.
- Estimated expenditure patterns.
- Provincial expenditure "multipliers".
- Employment characteristics.

This analysis is a very approximate procedure which is utilized solely to generate **comparative order-of-magnitude estimates** (i.e. how important would each of the irrigation developments be to M.D. of Acadia #34).

The pre-project baseline data that was used is shown in Table 10.5:

Table 10.5
Employment and Incomes - M.D. of Acadia #34

Sector	Number (%)
Agriculture/Resource-Based*	235 (65%)
Manufacturing/Construction*	10 (3%)
Service Industries*	115 (32%)
TOTAL*	360 (100%)
Average Earnings, All Persons with Earnings	$26,158
Average Earnings, Full Time/Full Year Workers	$28,472
Medium Household Income-All Households**	$51,677
Unemployment Rate (1996)**	0.0%
Participation Rate (1996)**	91.1%

* Data for 1995. ** Data for 2001. All Alberta estimate = $52,524.
***Comparable all-Alberta rates are about 5% and 72% respectively.

Multiplying average earnings (all persons) by total employment suggests an existing total income for the region of about $9.4 M per annum. And this, in turn, implies a Gross Domestic Product (GDP) of perhaps $16.5 M per annum with sales of maybe $ 37 M per annum.[6]

This resulting impact analysis highlights the following:

1) In terms of regional GDP, the annual stimulus during construction Years 1-3 would range from $1.5M to $2.6M per annum (9-16 % of current GDP levels in the region). Thereafter, during Years 4-53, this would probably drop to between $0.9M and $1.6M per annum (5-10 percent of current regional GDP).

2) Local employment would be expected to climb 7-12% during Years 1-3; 5-10% thereafter. This largely reflects construction employment by local personnel in Years 1-3 and additional local employment in agriculture thereafter.

3) Regional income, in turn, would be impacted in at least four different ways: 1) average income levels; 2) income stability; 3) income equity; and 4) savings and growth. During the construction period, regional incomes would be expected to increase an average of between $0.8M and $1.4M per year; a short-term stimulus of between 9% (Scenario 1) and 15% (Scenario 3) over current income levels in the region. This is a relatively large temporary impact. In the longer term, the additional irrigation development would likely add between $0.4M and $0.7M per year to local incomes. This 4 to 7 percent income improvement in each of Years 4-53 is particularly important because it represents a self-sustainable long-term improvement in regional income levels. Equally important, this could seemingly narrow the existing regional income disparity (with the rest of the province) by, say, 30 percent.

Additional details can be found in Appendix A, Sub-Section 4.2.

10.4.2 Regional Benefit-Cost Estimates

This analysis revises the provincial cash-flow calculations by acknowledging that regional impacts (as calculated in 10.3.2 preceeding) are a regional project benefit. The "spinoffs" considered are:

a) construction and subsequent O&M GDP captured by Acadia MD#34
b) farm capital investment and subsequent O&M GDP captured by the region.

This analysis reveals that from a regional perspective, the real economic internal rate of return (IRR, where B/C = 1 and NPV = 0) is equal to approximately 3% per annum, with Scenario 3 again most likely to slightly out-perform the other two development opportunities. This is about twice as large as the comparable provincial IRR estimate of about 1.5% per annum.

[6] Very approximate. Estimated by employing a GDP/income ratio of 1.75 and a sales/GDP ratio of 2.25. Estimates for specific sectors can be derived from the Provincial Accounts.

From a regional perspective the B/C ratios and NPV estimates also demonstrate a corresponding improvement, averaging about 0.95 if a 4 percent interest (discount) rate is employed. This is approximately 15% larger than the comparable provincial B/C estimate of about 0.80. Thus, from a regional perspective, for Scenarios 2 and 3, at a 3 percent discount rate, the B/C should exceed unity and the Net Present Value (over 53 years) should be positive. From this perspective, therefore, Scenarios 2 and 3 (with a slight preference to Scenario 3) could both be reasonably profitable investment opportunities.

The detailed calculations are again provided in Appendix A, Sub-Section 4.3.

11.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommendations of this conceptual study of irrigation development for the MD of Acadia:

1) Three irrigation development scenarios were selected within the study area, utilizing Class 2 & 3 lands, as follows:

   Scenario 1 5500 ha (13,600 acres)
   Scenario 2 8,904 ha (22,000 acres)
   Scenario 3 10,927 ha (27,000 acres)

2) Updated irrigation demand modelling by AAFRD determined that the overall average on-farm irrigation demand is 393 mm/ha (15 inches of water per irrigated acre), with the range being 200 to 535 mm/ha (8 to 21 inches per acre).

3) It was determined that a single river diversion site and a single storage reservoir site are more efficient and cost effective than multiple site options.

4) The majority of the development (72% – 84%, depending on the Scenario), will be gravity fed from the storage reservoir (Reservoir A1). Water for the remainder of the development is gravity fed to the existing Acadia Recreation Reservoir, and then pumped via a pressurized delivery system.

5) The proposed delivery and distribution system is designed to be very efficient (one major, lined canal; the rest of the delivery system and all laterals to be pipelines).

6) Diversion water from the Red Deer River and off-stream storage is required to meet irrigation demand requirements. The following is a summary of the diversion and storage requirements for each development scenario:

Scenario	River Diversion		Off-Stream Storage	
	Rate	Mean Annual Volume	Live	Total
1	2 m^3/s	21,200 dam^3	8,000 dam^3	13,500 dam^3
2	4 m^3/s	36,100 dam^3	12,300 dam^3	17,800dam^3
3	4 m^3/s	43,200 dam^3	17,000 dam^3	22,500dam^3

7) The WCO (water conservation objective) for the Red Deer River that was assumed in the SSRB WRMM for this study was the ***50% IFN***. The model included all existing water license allocations, as well as any current applications, within the river basin (updated to 2004), and took into account apportionment requirements to Saskatchewan and the additional in-stream flow required in the Red Deer River when the Bow and Oldman River contributions are low.

8) Based on the WCO assumed for this study, it was determined that there is sufficient water available in the Red Deer River for all three development scenarios, based on an accepted weighted average annual crop deficit of 100mm or greater, no more than 10% of the time.

9) Environmental and water quality impacts of the proposed development do not appear to be severe. It is anticipated that most of these issues can be accommodated and/or mitigated where necessary.

10) There are a number of historically significant sites in the area of some of the proposed infrastructure; specifically the river intake, supply pipeline and storage reservoir. The implications of these impacts need to be assessed further.

11) The following capital and annual O&M costs have been estimated for the three development scenarios:

	Scenario 1	Scenario 2	Scenario 3
Total Capital Cost	$54,600,000	$79,100,000	$96,100,000
Capital Cost per Irrigated Acre	$4,015	$3,595	$3,559
Annual O & M Cost	$1,650,000	$2,430,000	$2,860,000

12) The farm financial analysis determined the following:

a. On-farm profitability is highly dependent upon the size of farmer's contribution to irrigation system capital and operating costs. An annual operating cost contribution of about $50/acre is a likely maximum.
b. Compared to dryland, irrigation would approximately quadruple production levels while capital requirements are estimated to climb about 5 times; and labour requirements about 3 times. These requirements, in conjunction with other variables, would likely constrain irrigation development growth to about 3,000 acres per annum.
c. Assuming an off-farm annual O&M system contribution of $50/acre, irrigated crop production should be much more profitable than existing dryland crop production. The gross margin/acre would be expected to climb 6.5 times; the rate of return to capital about 3 times; and family income/acre about 12 times.

13) The regional impact analysis determined the following:

a. Depending upon the extent of the irrigation development, the short-term and long-term stimulus to the local economy would be substantial. GDP, income, and employment would probably increase, say, 10 – 15 percent per annum in the first few years; probably about 5% per year in subsequent years.
b. The estimated regional internal rate of return (where B = C) for Scenarios 2 and 3 is about 3 percent per annum and the regional B/C ratio (at a discount rate of 4%) is

about 0.95. From this perspective, therefore, Scenarios 2 and 3 (with a slight preference to Scenario 3) would both seem to be reasonably profitable investment opportunities.

14) When regional impacts are not considered a net benefit to the province, the provincial benefit-cost analysis tentatively concludes:

a. For Scenarios 2 and 3, the internal rate of return is probably about 1.46% and 1.59% per annum and the B/C ratio (at a discount rate of 4%) is probably equal to about 0.82.
b. The corresponding sensitivity analysis indicates that for Scenario 3 (the economically "best" case), the confidence band which brackets the internal rate of return (IRR) of 1.59% could be as low as 1.0% and as high as 4.1% per annum. Similarly, the confidence band which brackets the B/C ratio of 0.82 (for a discount rate of 4%/annum) could be a low as 0.67 and as high as 1.01.

As such, even from provincial benefit-cost perspective, irrigation development in the M.D. of Acadia could be a reasonably profitable investment opportunity for the Province. This is particularly true if prevailing regional socio-economic disadvantages are also considered in the final decision-making process.

15) Alternative sources of revenue and/or funding for both the initial capital outlay and the annual operating costs (river pumping) would be required to prove economic viability of irrigation development within the MD of Acadia.

16) Subsequent to securing revenue and/or funding sources for the project, additional engineering and site investigations would be required to confirm the technical viability and cost of the project. This would include detailed geotechnical and site analysis for the reservoir, dams and diversion works; further assessment of distribution layout requirements; determination of local buy-in and interest in the development; securement of the required water allocation and diversion rate from the Red Deer River; and further historical and environmental assessments.

12.0 ADDITIONAL STUDY REQUIREMENTS

12.1 General

There are a number of issues that could significantly impact the economic and/or technical viability of irrigation development within the MD of Acadia. As indicated in Section 11, alternative sources of revenue and/or alternate funding for both the initial capital outlay and the annual operating costs (in particular the river pumping) would be required to prove economic viability. Securing the required water allocation and diversion rate from the Red Deer River is of utmost importance and further engineering, historical and environmental assessments are also required to improve the level of confidence in the estimated cost and technical viability of the proposed development.

12.2 Water License Application

The first step in confirming the viability of the proposed irrigation development and ensuring advancement of this project would be to secure the diversion rate and annual allocation required from the Red Deer River. This is of particular importance since runoff into the proposed reservoir was determined to be negligible and insufficient to meet the project's demand requirements. Therefore, the viability of the entire project rides on securing a stable and reliable source of water from the Red Deer River. On this basis, an application to Alberta Environment should be made for diversion from the Red Deer River as soon as possible.

The river diversion rate and allocation required will be dependent on the final development area (scenario) selected, and the capacity of the storage reservoir(s). Scenario 3 was the largest and most economical development alternative considered in this report (10,927 hectares). The preliminary WRMM modelling determined that a diversion rate of 4 m^3/s and a mean annual diversion allocation of 43,200 dam^3 were required from the Red Deer River for Scenario 3. This was based on live reservoir storage of 17,000 dam^3. If it is determined in preliminary design that this volume of reservoir storage is not technically feasible, the size of the proposed development would have to be reduced accordingly.

This report can be used to support the water license application process. It is anticipated that additional WRMM modelling may be requested by AENV as part of the application process, to verify the impact that the project may have on junior licensees along the Red Deer and Oldman Rivers (refer to Appendix E for more information).

12.3 Preliminary Engineering Study

12.3.1 Background

The conceptual report determined that an irrigation development in the MD is technically viable from a conceptual engineering perspective. However, the acquisition and analysis of more precise physical information at a preliminary design level is required in order to verify the assumptions made in this report. In particular, the technical feasibility and cost of the supply and storage component of the proposed system (river diversion, supply pipeline and storage reservoir) must be considered in more detail. The supply and storage components have the most potential for significant impact on the projects' viability in terms of aquatic, environmental and historical resources, and also have the most uncertainty in terms of physical restraints. The physical restraint concerns include:

i) geotechnical - dam stability, reservoir seepage, river bank stability along pipeline route, etc;
ii) topographic – storage capacity in reservoir, ability to gravity feed distribution system, etc.;
iii) river intake viability – sediment loading, riverbank erosion, fishery requirements, etc.

A preliminary engineering study will be required for the entire project, however, since the supply and storage components carry the most uncertainty at the conceptual level, it is recommended that the preliminary engineering study be undertaken under a phased approach:

Phase I	-	Supply and Storage System
Phase II	-	Distribution System

It is also recommended that the next stage of historical and environmental assessments be included as part of the preliminary engineering studies, to ensure that the location of alignments, intake, dams, etc. in the study consider the engineering physical requirements and the environment/historical impacts.

12.3.2 Phase 1 Preliminary Engineering Study

Prior to implementing the Phase I preliminary engineering study, the following requirements should be considered:

- secure a water license
- submit the Historical Resources Overview (HRO) completed for this report (included in Appendix H) to Alberta Community Development and verify the next level of assessment required
- verify local landowner interest
- choose the development scenario to pursue in subsequent studies based on water license application, landowner interest responses and land classification requirements (note:

currently a level III land classification for lands in TWP 24 & 25 – Range 1 have not been completed)

- investigate alternate revenue sources and spin-off benefits to assist in lobby for short term and long term funding sources
- develop detailed terms of reference for the Phase 1 preliminary engineering study, based on the findings of the above and the general requirements identified in this section

The Phase I Preliminary Engineering Study should include the river diversion system, supply pipeline and storage reservoir (Reservoir A1). An order of magnitude estimate of the cost for preliminary engineering studies is typically 2-4% of the capital cost for the project. Based on the work identified in this report for the intake, supply system and storage reservoir, it is anticipated that the Preliminary Engineering Study budget for Phase I should be in the order of $1.2 million (+/- 20%).

The following provides a brief summary of the work that should be included in the Phase I Preliminary Engineering Program:

1) Study Area

- Includes the tributary containing the proposed Reservoir A1 and all feasible supply pipeline and river intake alignment routes to feed this storage reservoir site.

2) Hydrology

- Review and confirm that the hydrology analysis completed in the Conceptual Design Report is representative of the runoff events for the storage reservoir dam site.

3) Mapping

- Provide corrected photo-mosaic mapping of the area encompassing the reservoir site and all potential supply pipeline and intake locations with 1.0 metre contour intervals to +/- 0.5m vertical accuracy(utilizing GPS ground control and aerial photography)
- Provide site specific surveys (GPS) at the dam-site and river intake structures.
- Provide GPS survey of critical points along the proposed distribution system main canal alignments to verify the assumptions made in the conceptual report in regards to gravity delivery out of the reservoir

4) Geotechnical Investigations

- Develop and implement a drilling program for the proposed river intake site, supply pipeline route and reservoir damsite(s).
    - Piezometers are to be installed and monitored for the duration of the study.
    - Log bore holes, identify bulk densities, moisture contents, grain size analysis, soil permeability and atterberg limits.
    - The drill holes should include standard penetration tests and be to sufficient depths to determine the foundation conditions, stability factors of safety, etc. for the specific works.

- Provide a test pitting program (backhoe) for verification of borrow materials and the water holding capabilities of the reservoir.
  - Log test pits, identify moisture contents, grain size analysis, atterberg limits and soil permeability on representative samples.

5) Model Simulations

- Review the existing simulation model (WRMM) to ensure model is representative of the system and re-run as required to take into account water license conditions, final development area and storage reservoir modifications.

6) Diversion Works

- Complete preliminary design of the river intake diversion works on the Red Deer River.
- Optimize the location of the intake site relative to river engineering (sedimentation, bank erosion, bed scour, etc.), supply pipeline alignment, and minimizing environmental, historical resource and fishery impacts.
- Determine and account for accommodation of fish and other aquatic habitat considerations.
- Determine and account for operation and maintenance considerations, including silt deposition, accommodation of aquatic weeds and debris, ice forces and low river water levels.
- Determine optimal number and size of pumps in terms of the variability in flow requirements and energy cost considerations.
- Determine pump station layout and take into account access and power supply requirements.

7) Supply Pipeline

- Complete preliminary design of the supply pipeline from the river intake to the storage reservoir.
- Optimize the pipeline alignment relative to the location of the river intake and storage reservoir, constructability out of the river valley, erosion and geotechnical considerations, and minimizing historical resource and environmental impacts.
- Optimize size and number of pipes, as well as pipe material.
- Determine air/vacuum, and pipeline surge protection requirements.

8) Storage Reservoir

- Complete preliminary design of the storage reservoir and associated infrastructure.
- Determine the optimum storage capacity, location and configuration of the main damsite, as well as the upstream containment dam (west dam) and its infrastructure.
- Estimate the potential seepage losses from the reservoir and its potential impact on the Red Deer River valley bank.
- Review and verify the consequence classification of the dams in accordance to Canadian Dam Safety Association (CDA) Guidelines.

- Determine the optimal cross-section, foundation, drainage and instrumentation requirements for the dams based on CDA Guidelines for the consequence classification of the dam.
- Determine flow management facilities for the canal outlet structures and spillways for the dams as required.
- Assess impacts and mitigation requirements on utilities, pipelines and landowners including access and construction materials.

9) Environmental and Historical Impacts

- Complete a screening level Environmental Assessment (EA) on the river intake, supply pipeline alignment and storage reservoir site.
    - Aquatic portion should take into account sediment loading, protection of fish, high pumping requirements and potential construction related issues.
    - Terrestrial ecology and vertebrate Species at Risk component should consider the proposed supply pipeline alignment and reservoir storage (including borrow site) requirements.
- Complete a Historical Resources Impact Assessment (HRIA) for the proposed river intake, supply pipeline and storage reservoir sites (or as otherwise advised by Alberta Community Development).
- Review water quality implications based on the findings of the preliminary engineering design.
- Develop a water quality monitoring program (if required) to allow determination of water quality impacts and potential deterioration within the proposed irrigation system.
- Determine the requirements for the next step in environmental assessments (including fishery monitoring and studies) and historical resources investigations.

10) Cost Estimating / Reporting

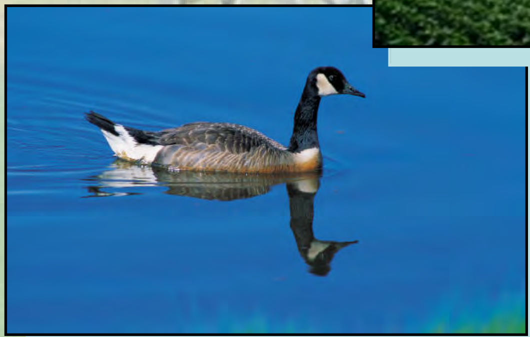
- Determine capital costs for all components of the Phase I works. Consideration must be given to source of materials, number of contracts, economic conditions and proposed time tables.
- Determine operation and maintenance costs for the river intake, supply pipeline and storage reservoir components of the system.
- Review and re-evaluate the economic analysis completed in the conceptual study with the updated information from the preliminary design, as required.
- Prepare a Phase I preliminary engineering report, complete with data, cost information and drawings, detailing the preliminary designs.
- Prepare terms of reference for the Phase II preliminary engineering study (distribution system), as well as any other assessment or investigation determined to be necessary on the Phase I works based on the findings of the Phase I study.

12.3.3 Phase II Preliminary Engineering Study

The Phase II preliminary engineering study should be undertaken after the completion of the Phase I study and verification of the technical and economic viability of the Phase I components. Depending on the findings of the Phase I study, it is possible that further assessments (geotechnical, aquatic, environment or historical resource) may be necessary prior to implementing the Phase II study.

MUNICIPAL DISTRICT OF ACADIA No. 34
IRRIGATION DEVELOPMENT STUDY
Final Report (Appendices) - Volume II of II
June, 2005




Prepared by:

mpe ENGINEERING LTD.

MUNICIPAL DISTRICT OF ACADIA NO. 34

IRRIGATION DEVELOPMENT STUDY

Final Report - Appendices

VOLUME II of II

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MPE Engineering Ltd.

June 2005

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Calgary, Alberta

VOLUME II of II

TABLE OF CONTENTS

APPENDIX A

Economic Analysis Report

APPENDIX A
FINANCIAL & ECONOMIC ANALYSIS

1. OVERVIEW

1.1 Background

A multi-disciplinary pre-feasibility analysis (including an economic analysis) of potential irrigation development in the region was completed in 1987.[1] This economic analysis concluded that the four specific irrigation development proposals evaluated could only be considered economically feasible if a real rate of return of 1 to 3 percent per annum was politically acceptable (p. 11-8). A follow-up financial feasibility component prepared in 1988 further suggested that irrigation development rates might be thwarted by the rather modest projected on-farm incremental financial returns to irrigation.[2]

But because many of the parameters and assumptions underlying these earlier economic studies have now changed, a careful and more comprehensive re-assessment is warranted. Additionally, an economic regional impact assessment should also be conducted. This up-dated and more comprehensive re-assessment is provided following.

1.2 Development Alternatives

The three principal irrigation development scenarios evaluated from an economic perspective are:

- Scenario 1: 5,500 ha. (13,600 acres)
- Scenario 2: 8,900 ha. (22,000 acres)
- Scenario 3: 10,850 ha. (27,000 acres)

All three scenarios utilize a single new storage reservoir which feeds, via gravity, two blocks west of Kennedy Creek and a small pressurized system that feeds out of the existing MD recreational reservoir. Scenarios 2 and 3 include a siphon that feeds an irrigation block east of Kennedy Coulee. For Scenario 3, an additional block east of Kennedy Coulee is fed from the MD reservoir via a pressurized pipeline. These proposed irrigation blocks are illustrated in Figure 4.2 of the main report and described in greater detail in other sections of the report.

1.3 Analytical Framework

The analysis is divided into three parts:

[1] Acres International, **Water Supply to the Special Areas, Phase 1 Study Report**, Alberta Environment, Calgary, May 1987.
[2] Heikkila, R., **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**, Alberta Agriculture, Edmonton, September 1988.

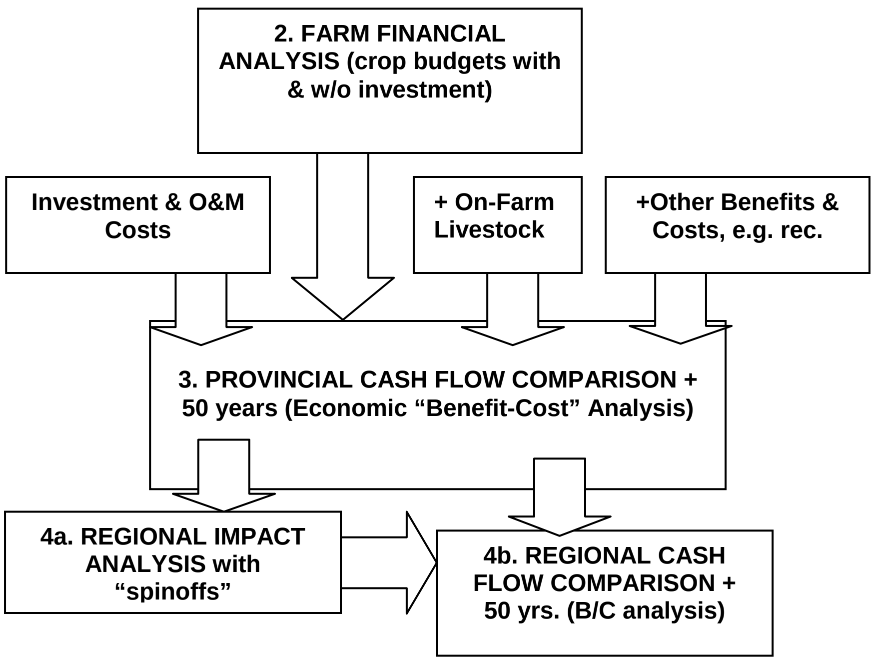
- Sub-Section 2. Farm Financial Analysis–a financial analysis of what irrigation would mean to existing dryland farmers in the project area in MD Acadia #34. This focuses on production and profitability, as well as required structural changes.

- Sub-Section 3. Provincial Benefit-Cost Analysis –an economic cash flow analysis comparing the incremental real direct benefits over time to the incremental real direct costs over time. This employs a provincial accounting stance; not a regional perspective.

- Sub-Section 4. Regional Impact Analysis –an analysis of how irrigation development would impact the M.D. of Acadia region, both in the short-term and in the long term. The focus here is on income and employment growth in the project area. In this context, a Regional Benefit-Cost comparison is also conducted.

These analytical components are linked to one another so there is a logical and numerical consistency throughout. Sub-Section 3 is developed utilizing the data from Sub-Section 2; Sub-Section 4 is developed utilizing the data from Sub-Section 3. Figure 1.1 illustrates these inter-dependencies:

Figure 1.1:



2. FARM FINANCIAL ANALYSIS

2.1 Introduction

The purpose of this Sub-Section is to illustrate the net financial gains or losses that could result if existing dryland crop production was converted to irrigation in MD of Acadia #34. Typical budgets are developed for various crops under both dryland and irrigation to determine profitability and structural characteristics under each scenario. These calculations, however, are only **order-of-magnitude comparisons** to highlight the significant on-farm changes which might be expected.

Actual and expected crop mixes are utilized to estimate a regional “average”. This does not necessarily represent a “typical” or “representative” farm situation. For each crop, the basic data required are: a) input quantities and prices; b) product prices and yields; and c) capital-labour structure. Each respective crop budget reflects the technology (i.e. input-output structure) employed. Only existing (secondary) data are utilized.

The accounting practices employed are generally consistent with a 1988 AAFRD study entitled **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**.[3]

2.2 Dryland Crop Production

2.2.1 Existing Cropping Patterns

Existing cropping patterns have been estimated for the proposed irrigation area. Areal photography indicates that alfalfa/hay makes up about 7.5% of the area, native grass about 3.8% and cultivated land the remainder. (MPE, 1/05) The composition of the cultivated land, excluding summerfallow, was then estimated from 2001 census data for MD of Acadia #34 and SA#3. Summerfallow is excluded because the input-output data (see following) are for stubble crops; not fallow crops. The estimates provided in Table 2.1 indicate that almost 60% of the dryland is typically wheat; another 20% barley.

Table 2.1. Existing Dryland Crop Mix, Acadia Valley Project Area

Crop		Area (%)
Spring Wheat		39.4%
Durum Wheat		19.7%
Barley*		20.3%
Canola**		5.3%
Dry Field Peas		2.0%
Chickpeas		2.0%
Alfalfa/Hay/Mixes***		7.5%
Native Pasture		3.8%
Summerfallow****		
TOTAL		100%

* Includes oats, mixed grain, triticale, and rye.

** Includes yellow mustard and canary seed.

*** Includes other tame hay and forage seed.

**** Excluded since crop budgets are for stubble crops.

Sources:

1. Native grass, forages, and crop total percentages: MPE Engineering, 1/05.

2.Crops: AAFRD/Statistics Canada, **2001 Census of Agriculture for Alberta, I.D., M.D., and County Data,** Agdex 852-1, Edmonton, 2002.

[3] Heikkila, R., **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**, AAFRD, Edmonton, September 1988.

These percentages are employed to generate a regional “average” cost and return estimate for dryland crop production in the region. This does not reflect actual crop rotations.

2.2.2 Annual Input Costs

Input cost estimates are based on a specific technology (input levels) and cost structure. For the crops being considered (see above), these are generally taken directly from AAFRD 2004 Production Cost and Return data for stubble seeded crops in the brown soil zone. www.agric.ab.ca.

2.2.3 Projected Annual Revenue

Annual revenue is a function of price X yield.

2.2.3.1 *Crop Prices*

Crop prices fluctuate considerably and future prices are unknown. This on-farm financial analysis generally employs average nominal crop prices for the 10-year period 1994-2003. (AAFRD **Statistical Yearbook**) The prices of particular interest are:

CWRS Wheat	$4.25/bushel
Durum Wheat	4.50/bushel
Barley (all)	2.60/bushel
Mustard	18 cents/lb.
Canola	7.00/bushel
Field Peas	4.61/bushel
Chickpeas	20 cents/lb.
Alfalfa/Hay	$85/ton

Details are attached, Attachment A-1.

2.2.3.2 *Crop Yields*

Dryland crop yields in the region are relatively low and highly variable. Average crop yields have been estimated by the Alberta Financial Services Corporation (AFSC Crop Insurance) and five year yield fluctuations can be calculated from this same source. www.afsc.ca. Average yields for various dryland crops in this semi-arid region are indicated in Table 2.2. The extreme variability in crop yields is also illustrated in accompanying Figure 2.2.

Table 2.2. Dryland Crop Yields, 1998-2002, AFSC Long-Term Averages (stubble, bushels/acre)

Crop Category	Crop	Crop Risk Area #9***	Crop Risk Area #4***	Variation 1 yr in 3**
Wheat	All Wheat	23.0	18.8	10.0
Barley	All Barley	36.2	22.1	19.4
Other Cereals	D. Wheat		17.9	11
Alfalfa/Mixture*	Hay>50% legume	1.52	1.69	****
Hay Grass*	Hay<50% legume	1.10	1.18	****
Canola/Mustard	Canola	16.0	15.2	8.46
Pulses	Field Pea		16.6	15

* Imperial tons. Forage Risk Area #7.

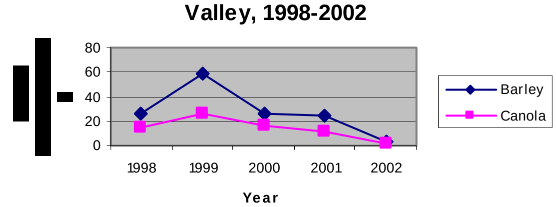
** One standard deviation. Data for wheat and pulses from Risk Area #4.

*** Crop Risk Area #9 = M.D. of Acadia & north. Crop Risk Area #4 =SE.

**** Crop yields in drought year 2002 were 0.4 and 0.3 tons, respectively.

Source: Alberta Financial Services Corporation. Website www.afsc.ca.

Figure 2.2. Barley & Canola Yields, Acadia Valley, 1998-2002



Source: website www.afsc.ca., Risk Area #9.

Source: **The Alberta Express**, 2004. (A good year.)

Source: **The Alberta Express**, 2004. (A good year.)

Wheat and barley average about 23 and 36 bushels/acre, respectively. Alfalfa and hay average about 1.52 and 1.1 tons/acre, respectively. These averages, however, disguise the acute yield variability which exists between years. For example, in the case of CWRS wheat, in one year out of every three, farmers can expect either 13 bushels or 33 bushels/acre. In one year out of every twenty, they can expect between 3 bushels and 43 bushels per acre. The year 1999 approx. represented a 1/20 good year; the year 2002 approx. represented a 1/20 bad year. The severe drought of 2002 resulted in almost no crop being harvested. As a general rule, in one year out of every three crop yields fluctuate about 50 percent.

2.2.4 Capital-Labour Requirements

Approximate per-acre capital values are estimated from **Census of Agriculture 2001** and **Agricultural Statistics Yearbook 2003.**[4] These are as follows:

Land	$292/acre
Buildings	32
Machinery	141
SUB-TOTAL	$465/acre

This average capital structure for MD of Acadia #34 is fairly consistent with dryland crop production characteristics in other semi-arid regions of the province.[5]

Labour requirements are estimated from various AAFRD cost-and-return studies and average (depending on the crop) about 1.25 hours per acre. Typically, this also involves about 1 hour of unpaid labour and 0.25 hours of paid labour (family or non-family). Expensed at $12/acre. this is generally consistent with current crop budget estimates. www.agric.ab.ca.

2.2.5 Crop Budgets

Based on the (above) input-output estimates, crop budgets for seven representative dryland crops were prepared: CWRS wheat, durum wheat, barley, mustard, field peas, chickpeas, and alfalfa/hay. These crops make up about 96% of the seeded area, with a residual area in native grass.

A weighted average of individual crops is generated to represent "average" measures of profitability, either across crops or over time. This is important to avoid having an extreme estimate (say $1.50 barley or $5 canola) greatly distort the overall analysis. Also provided are aggregate average estimates for 132 acres (comparable to the area covered by a ¼ mile centre pivot sprinkler) and 1000 acres to provide some indication of aggregate values for dryland farms of this size. These or any other multiples of the per-acre analysis are implicitly ignoring scale effects on the respective technology employed, unit input costs, unit product prices, crop yields, and so on.

The summary tabulations are provided in accompanying Table 2.3.

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[4] AAFRD, **2001 Census of Agriculture for Alberta**, Agdex 852-1, Edmonton, 2003; and AAFRD, **Agriculture Statistics Yearbook, 2003,** Edmonton, July 2004. Livestock and machinery estimates are based on total value/owned land. Land estimates are based on the average value of actual land transactions, all CLI classes, MD Acadia #34, 2003. Building values are assumed by the authors to equal 10% of the total land value.

[5] See, for example: **Milk River Basin Preliminary Feasibility Study,** Klohn Crippen/Alberta Environment, Calgary, 2004.

Table 2.3. On-Farm Crop Budgets for Existing Dryland Crop Production in M.D. of Acadia* $2004-05 per acre

Item	Spring Wheat #1 13.5%	Durum Wheat #1 13%	Barley	Yellow Mustard	Field Peas	Chickpeas	Alfalfa & Mixed Hay**	CROPS, Weighted Average	132 ACRES	1000 ACRES***	PER ACRE: EITHER 1 Year in 3 BAD	PER ACRE: OR 1 Year in 3 GOOD	PER ACRE: EITHER 1 Year in 20 BAD	PER ACRE: OR 1 Year in 20 GOOD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CROP MIX (excl. summerfallow) (%)	39.4%	19.7%	20.3%	5.3%	2.0%	2.0%	11.3%	100%						
(A) 1. Crop Sales	97.75	103.50	93.60	126.00	92.20	140.00	110.50							
Yield (stubble-seeded)	23.00	23.00	36.00	700.00	20.00	700.00	1.30							
Market Price	4.25	4.50	2.60	0.18	4.61	0.20	85.00							
2. Other Revenue	12.97	12.97	20.30	0.00	16.00	0.00	0.00							
GROSS RETURN	**110.72**	**116.47**	**113.90**	**126.00**	**108.20**	**140.00**	**110.50**	**113.82**	**15024**	**113820**	64.88	162.76	17.07	212.84
(B) 1. Seed	9.00	10.00	7.00	10.00	25.00	65.00	5.00							
2. Fertilizer	**23.60**	**23.60**	**23.60**	**26.30**	**5.60**	**5.60**	**13.50**							
Nitrogen	18.00	18.00	18.00	18.00	0.00	0.00	13.50							
Phosphorus	5.60	5.60	5.60	5.60	5.60	5.60	0.00							
Potassium	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
Sulphur	0.00	0.00	0.00	2.70	0.00	0.00	0.00							
Micros	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
3. Herbicides	**23.50**	**23.50**	**12.00**	**24.50**	**39.50**	**29.50**	**2.50**							
Pre-Seed	4.50	4.50	4.50	4.50	4.50	4.50	2.50							
In Crop	19.00	19.00	7.50	20.00	25.00	25.00	0.00							
Pre-Harvest	0.00	0.00	0.00	0.00	10.00	0.00	0.00							
4. Baling Twine/Additive							6.37							
6. Crop Insurance	8.00	9.00	9.00	12.00	8.00	10.00	0.00	7.75						
7. Trucking/Storage/Fees/Marketing	3.76	3.76	4.70	1.90	3.27	1.90	5.20							
8. Fuel, Oil & Lube	6.30	6.30	6.30	6.30	6.30	6.30	5.25							
9. Repairs - Machinery	6.25	6.25	6.25	6.25	7.25	7.25	6.25							
10. Repairs - Buildings	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
11. Utilities & Misc. Expenses	4.00	4.00	4.00	4.00	4.00	4.00	4.00							
12. Custom Work/Special	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
13. Operating Interest Paid	2.21	2.24	1.80	2.35	2.66	3.56	1.32							
14. Paid Labour & Benefits	2.76	2.76	3.60	4.68	5.40	4.68	3.60							
OPERATING EXPENSES	**90.37**	**92.40**	**79.26**	**99.29**	**107.97**	**138.79**	**53.99**	**86.20**	**11378**	**86198**	86.20	86.20	86.20	86.20
(C) FIXED COSTS														
16. Land Taxes, Licenses, & Insurance	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00			4.00	4.00	4.00	4.00
FIXED COSTS	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**528**	**4000**	4.00	4.00	4.00	4.00
(D) CAPITAL COSTS														
17. Equipment & Bldg. Interest	4.33	4.33	4.33	4.33	4.33	4.33	4.33	4.33			4.33	4.33	4.33	4.33
18. Building & Equipment Depreciation	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70			15.71	15.71	15.71	15.71
TOTAL CAPITAL COSTS	**20.03**	**20.03**	**20.03**	**20.03**	**20.03**	**20.03**	**20.03**	**20.03**	**2643**	**20025**	**20.03**	**20.03**	**20.03**	**20.03**
(E) CASH COSTS (B+C)	94.37	96.40	83.26	103.29	111.97	142.79	57.99	90.20	**11906**	**90198**	94.52	94.52	94.52	94.52
(F) TOTAL PRODUCTION COSTS (B+C+D+I)	126.40	128.43	115.28	131.59	142.80	171.10	90.01	121.93	**16094**	**121928**	123.48	123.48	123.48	123.48
(G) GROSS MARGIN (A-E)*	16.35	20.07	30.65	22.71	-3.77	-2.79	52.51	**23.62**	**3118**	**23622**	-29.65	68.24	-77.45	118.32
(H) ANNUAL CASH FLOW (A-B-C-D)	-3.68	0.04	10.62	2.69	-23.80	-22.82	32.49	3.60	**475**	**3597**	-45.35	52.53	-93.16	102.61
(I) UNPAID FAMILY LABOUR (non-cash)	12.00	12.00	12.00	8.28	10.80	8.28	12.00	11.70	**1545**	**11704**	13.25	13.25	13.25	13.25
(J) MEASURES OF FARM PROFITABILITY														
a. Return to Capital (A-B-C-I)**	4.35	8.07	18.65	14.43	-14.57	-11.07	40.51	11.92	1573	11918	-38.57	59.32	-86.38	109.40
b. Percent Return to Capital**	0.9%	1.7%	4.0%	3.1%	-3.1%	-2.4%	8.7%	2.6%	2.6%	2.6%	-8.3%	12.8%	-18.6%	23.5%
c. Return to Equity (A-B-C-D-I)***	-15.68	-11.96	-1.38	-5.59	-34.60	-31.10	20.49	-8.11	-1070	-8107	-58.60	39.28	-106.41	89.36
d. Family Income (A-B-C-D)****	-3.68	0.04	10.62	2.69	-23.80	-22.82	32.49	3.60	475	3597	-45.35	52.53	-93.16	102.61
BACKGROUND DATA:														
INVESTMENT														
Land	292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00	38544	292000	292.0	292.0	292.0	292.0
Buildings	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	4224	32000	32.0	32.0	32.0	32.0
Machinery	141.00	141.00	141.00	141.00	141.00	141.00	141.00	141.00	18612	141000	141.0	141.0	141.0	141.0
Livestock														
TOTAL	465.00	465.00	465.00	465.00	465.00	465.00	465.00	465.00	61380	465000	465.06	465.06	465.06	465.06
LABOUR														
Hired Labour (hours)	0.23	0.23	0.3	0.39	0.45	0.39	0.3	0.27	35	268				
Unpaid Labour (hours)	1	1	1	0.69	0.90	0.69	1.0	0.98	129	975				
Total Labour (hrs./acre/yr.)	1.23	1.23	1.30	1.08	1.35	1.08	1.30	1.24	164	1244				
Rate/Hour	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00						
Straw/Aftermath Yield (tonnes)	0.65	0.649	1.015	0.0	0.4	0	0							
Market Price ($/tonne)	20.00	20.00	20.00	0.00	40.00	0.00	0.00							

* For sources and methodological details, see Accompanying Footnotes, Attachment A-4.

** Includes 3.8% native grass.

*** Assuming no economies-of-scale.

2.2.6 Measures of Profitability

The resulting measures of profitability with dryland crop production (again see Table 2.3) generally indicate a relatively low average return to both capital and on-farm labour and management. The rate of return to capital is estimated to be about 2.6% per annum and the return to equity a negative $8.11/acre/year. The annual return to on-farm labour and management is estimated to be about $4/acre/year or, for a 1000 acre farm, about $4,000 per year.

But these are averages which are almost meaningless figures in an area where large yearly fluctuations in dryland yields are the norm. Some very approximate estimates of how these fluctuations translate to the "bottom line" are as follows: (per acre)

Criteria	1 in 3 Bad or Good Year	1 in 20 Bad or Good Year
$ Return to Capital	-$39 or +$59	-$86 or +$109
% Return to Capital	-8.3% or +12.8%	-18.6% or +23.5%
$ Return to Equity	-$59 or +$39	-$106 or +$89
$ Family Income	-$45 or +$53	-$93 or +$103

AAFRD estimates that the risk of not covering all costs (i.e. not having a positive cash flow or positive family income) on dryland operations in central and southern Alberta in any given year is in the vicinity of 10 to 30 percent.[6] The risk under dryland conditions in MD of Acadia #34 may be even higher.

2.3 Irrigated Crop Production

2.3.1 Projected Cropping Patterns

AAFRD/Lethbridge has projected that cropping patterns under irrigation will probably be approximately as indicated in Table 2.4. This is based on their own experience with past irrigation developments in Southern Alberta. It is this crop mix which is utilized in determining gross irrigation water requirements in the project area. (see elsewhere)

Table 2.4. Projected Crop Mix with Irrigation, M.D. of Acadia

Crop Group	Crop Name	Crop Area (%)
Cereal	Barley	19.40%
	Wheat	8.80%
Cereal Sub-total		**28.20%**
Forage	Alfalfa (2-cut)	45.8%
	Alfalfa Hay	8.4%
	Barley Silage	3.8%
	Grass Hay	8.7%
	Tame Pasture	1.2%
Forage Sub-total		**67.9%**
Oilseed	Canola	3.8%
Oilseed Sub-total		**3.8%**
Total		**100.0%**

Source: AAFRD IPM modelling. For details, see elsewhere.

[6] FBMB/Crop Insurance Review, 1992.

2.3.2 Annual Production Costs

Input cost estimates (exclusive of water) are based on a specific technology (input levels) and cost structure for irrigated crop production. For the crops here considered (see above), these are generally taken directly from AAFRD 2004 Production Cost and Return data for irrigated crops in Alberta. www.agric.ab.ca.

2.3.3 Annual On-Farm Irrigation Costs

On-farm operating and maintenance (O&M) cost for irrigation is expected to amount to about $46/acre/year. This includes a pumping cost of about $30/acre for an average gross water application of 15.5" (393mm) per annum (Appendix Table A-2).

2.3.4 Annual Off-Farm Irrigation System Cost

The contribution the farmer makes to off-farm system costs depends upon the financial-institutional structure established for M.D. of Acadia and this is still not known. There is no province-wide formula. What we do know is that total annual operating and maintenance costs for the alternative systems will be approximately as indicated in Table 2.5.

Table 2.5. Annual Operation & Maintenance Costs, M.D. of Acadia $2005

Item	Scenario 1	Scenario 2	Scenario 3
Main Pump Station at Red Deer River-Energy*	$1,111,000	$1,705,000	$1,934,000
Pump Station, Pipeline, & Reservoir**	$235,400	$295,400	$299,700
Distribution System***	$204,000	$330,000	$405,000
Municipal Pump Station*	$98,600	$98,600	$217,300
TOTAL	**$1,650,000**	**$2,430,000**	**$2,860,000**
Total/Acre/Year	$121.32	$110.45	$105.93

* O&M + Energy Surcharge + $.075/kWh. **2.5% of pumpstation capital cost; 0.25% of pipeline capital cost and 0.50% of reservoir capital cost. ***$15/acre.

Source: Table 3.3.

On this basis, three hypothetical "rate schedules" were constructed:[1,2]

- Rate Schedule #1: All farmers annually pay all O&M costs (includes 100% of Headworks O & M), less the net of the costs associated with the pressurized component to select farmers @ $30/acre
- Rate Schedule #2: All farmers annually pay subsidized O&M costs (includes 25% of Headworks O & M), less the net of the costs associated with the pressurized component to select farmers @ $30/acre.
- Rate Schedule #3: All farmers annually pay significantly subsidized O&M costs (exclusive of all headwork O&M costs) less the net of costs associated with the pressurized component to select farmers @ $30/acre

[1]All the rate schedules assume that all farmers associated with Blocks 3 and 4 pay a surcharge of $30/acre for the benefit of a system with sufficient pressure to operate their pivots. Costs associated with these surcharge rates ($75,000 for Scenarios 1 and 2 and $225,000 for Scenario 3) were subtracted from the total O & M costs in establishing the three rate schedules.

[2]The rate schedules do not include any charges that may apply to funding the capital infrastructure works. The capital costs are assumed to be funded separately.

This would mean that irrigation farmers would ultimately be responsible for one of the following annual O&M system costs: (per acre)

Rate Schedule	Scenario 1	Scenario 2	Scenario 3
#1	$115.81	$107.05	$97.59
#2	$41.56	$38.85	$35.55
#3	$16.74	$16.07	$14.71

2.3.5 Projected Annual Revenue

Annual revenue again depends upon product prices and irrigated crop yields.

2.3.5.1 *Crop Prices*

Projected crop prices for irrigated crops are based on the same 10-year averages as for dryland. (Section 2.2.3.1). Prices for the same crop for the two different technologies are generally assumed to be the same; for simplicity, it is assumed that there are no qualitative differences between irrigated and dryland crop production. The prices of particular interest (Section 2.3.1) are:

CWRS Wheat	$4.25/bushel
SWS Wheat	$4.00/bushel
Barley, all	$2.60/bushel
Alfalfa Hay	$90/ton
Grass Hay/Pasture	$80/ton
Barley Silage	$32/tonne

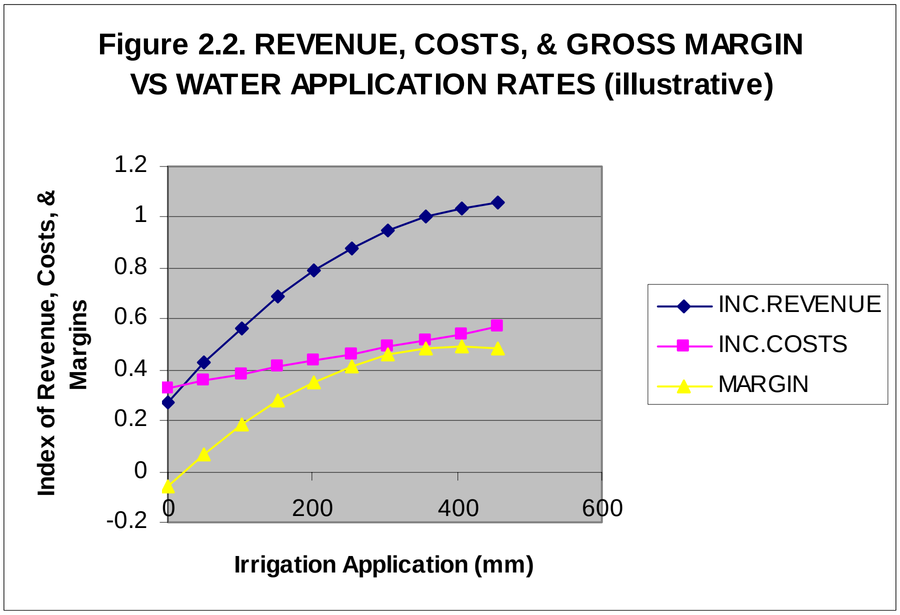
Additional details are provided in Attachment A-1.

2.3.5.2 *Crop Yields*

Irrigated crop yields are generally based on data for irrigated crops in Alberta, irrespective of where they are produced. www.agric.ab.ca These estimates are: (per acre)

CWRS Wheat	65 bushel
SWS Wheat	80 bushel
Barley, all	95 bushel
Alfalfa, 2-cut	6.5 ton
Alfalfa/Grass Hay	5 ton
Pasture	3.5 ton
Barley Silage	11 tonne

These yields are specific to the input levels expected regarding fertilizer, crop protection, and so forth (Section 2.3.2). They are also specific to water application rates (Section 2.3.3), here expected to average about 393 mm (or 15.5”) per year. These curvi-linear input-output relationships, holding all other variables constant, generally exhibit decreasing marginal incremental returns as the quantity of any particular factor of production is increased. (Figure2.2) The economically optimal input level is where the slope of the yield curve (dY/dX) is equal to the inverse price ratio (P_x/P_y). A maximum physical yield is only an optimum physical yield when an input is free.



This is a particularly important production characteristic when considering the impact of periodic water shortages on farm incomes.

2.3.6 Capital-Labour Requirements

Land/building and machinery requirements for irrigated crop production are estimated from AAFRD cost-of-production studies of irrigation farmers elsewhere in the province. The average cost of new irrigation equipment is a weighted average of AAFRD/Lethbridge estimates for the different types of irrigation system expected in Acadia Valley (5% hand, 10% wheel, 35% HP pivot, and 50% LP pivot). The resulting estimates are: (per acre)

Land	$600/acre
Buildings	100
Machinery	375
Irrigation Equip.	818
TOTAL	$1,893/acre

Details regarding projected irrigation equipment costs are provided in Attachment A-3.

Labour requirements are estimated from various AAFRD cost-and-return studies for irrigated crop production and average (depending on the crop) between 3 and 4 hours per acre per year. Typically, this also involves about 50% unpaid labour and 50% paid labour (family or non-family). Expensed at $12/acre/year, this is generally consistent with current crop budget estimates. www.agric.ab.ca.

2.3.7 Crop Budgets

Analogous to how the dryland crop budgets were estimated (Section 2.2.5), crop budgets for nine representative irrigated crops were also prepared: feed barley, CWRS wheat, SWS wheat, alfalfa (2 cut and hay), barley silage, grass hay, and tame pasture. Six of these nine crops, making up 87% of the total irrigated area, are crops which will probably be fed to livestock. Only three crops (CWRS wheat, SWS wheat, and canola) are considered cash crops.

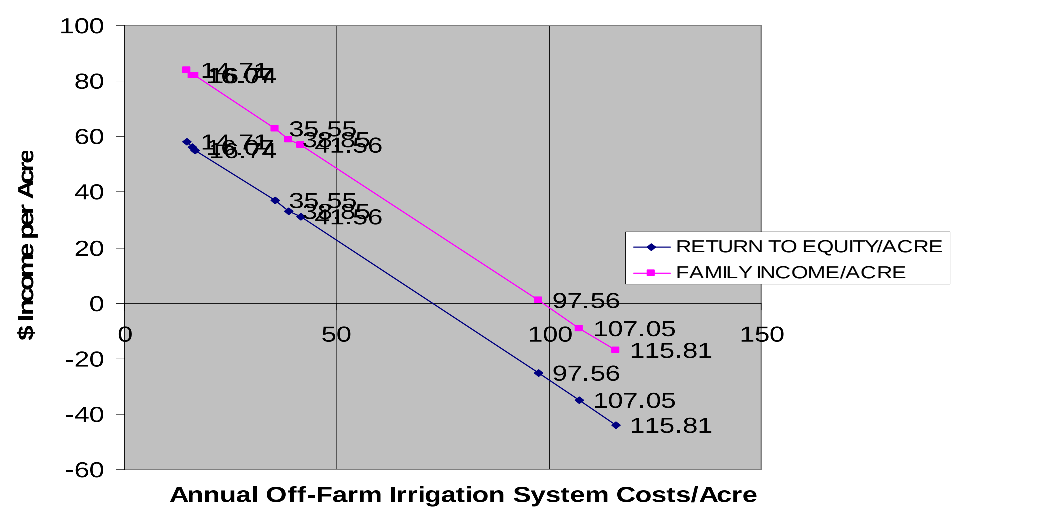
It is intended that a weighted average for irrigated crops represent "average" measures of profitability, either across crops or over time. Once again, this is important to avoid having an extreme estimate greatly distort the overall analysis. Aggregate average estimates.for 132 acres (comparable to the area covered by a ¼ mile pivot sprinkler) and 1000 acres are also calculated to provide some indication of aggregate values for irrigated farms of that size. These or any other multiples of the per-acre analysis are, again, implicitly ignoring scale effects on the respective technology employed, unit input costs, unit product prices, crop yields, and so on.

The illustrative budget provided following (Table 2.6) determines farm profitability if, in fact, the farmer's share of annual O&M system costs is approximately $50/acre/year.

2.3.8 Measures of Profitability

The profitability of irrigation will depend, first and foremost, on how much farmers contribute to annual off-farm system O&M. Thus, we have simulated how each of three hypothetical cost regimes (Section 2.3.4) would impact on per-acre profitability as defined by return-to-equity, farm family income, and return to capital (%).[7] The results of these simulations are illustrated in Figures 2.3 and 2.4 following:

Figure 2.3. FARM INCOME FOR DIFFERENT OFF-FARM IRRIGATION SYSTEM COSTS/ACRE/YEAR



[7] Return-to-equity = Revenue less Total Production Costs (=Variable Costs + Fixed Costs + Capital Costs + Unpaid Family Labour Costs). Family Income = Return to Equity + Return to Unpaid Family Labour.

Table 2.6. On-Farm Crop Budgets for Projected Irrigation Development in M.D. of Acadia* $2004-05/acre

I T E M	Feed Barley	HRS Wheat	SWS Wheat	Alfalfa 2-cut	Alfalfa Hay	Barley Silage	Grass Hay	Tame Pasture	H.T. Canola		CROPS Weighted Average	132 ACRES	1000 ACRES**
	1	2	3	4	5	6	7	8	9		10	11	12
PROJECTED CROP MIX	**19.4%**	**4.4%**	**4.4%**	**45.8%**	**8.4%**	**3.8%**	**8.7%**	**1.2%**	**3.8%**		**100%**		
(A) 1. Crop Sales	247.00	276.25	320.00	585.00	450.00	352.00	400.00	280.00	350.00		444.72		
Yield	95.00	65.00	80.00	6.50	5.00	11.00	5.00	3.50	50.00				
Market Price	2.60	4.25	4.00	90.00	90.00	32.00	80.00	80.00	7.00				
2. Other Revenue	51.46	35.21	43.33	0.00	0.00	0.00	0.00	0.00	0.00		13.44		
GROSS RETURN	**298.46**	**311.46**	**363.33**	**585.00**	**450.00**	**352.00**	**400.00**	**280.00**	**350.00**		**458.16**	**60,477**	**458,158**
(B) 1. Seed	12.50	15.00	16.25	10.00	10.00	12.50	2.50	10.00	24.00		10.94		
2. Fertilizer	**50.10**	**50.10**	**53.50**	**22.10**	**17.00**	**50.10**	**65.00**	**65.00**	**62.90**		**36.56**		
Nitrogen	40.00	40.00	42.00	0.00	0.00	40.00	48.00	48.00	46.00		19.39		
Phosphorus	8.40	8.40	9.80	16.38	12.60	8.40	12.60	12.60	9.80		12.93		
Potassium	1.70	1.70	1.70	2.21	1.70	1.70	1.70	1.70	1.70		1.93		
Sulphur	0.00	0.00	0.00	3.51	2.70	0.00	2.70	2.70	5.40		2.31		
Micros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
3. Herbicides	**24.50**	**28.50**	**28.50**	**2.25**	**2.25**	**12.00**	**2.25**	**0.00**	**39.50**		**10.63**		
Pre-Seed	4.50	4.50	4.50	2.25	2.25	4.50	2.25	0.00	4.50		3.03		
In Crop	20.00	24.00	24.00	0.00	0.00	7.50	0.00	0.00	35.00		7.61		
Pre-Harvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
4. Baling Twine/Additive				13.00	10.00		10.00				7.66		
5. Irrigation: Pumping Costs - On-Farm	23.86	23.86	28.62	62.03	47.72	19.09	47.72	33.40	33.40	45.91	45.91		
5.a. Irrigation Sysem - Pumping + O&M	25.99	25.99	31.17	67.56	51.97	20.79	51.97	36.37	36.37	49.99	50.00		
6. Crop Insurance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
7. Trucking/Storage/Fees/Marketing	12.41	10.61	13.06	26.00	20.00	20.00	20.00	0.00	6.80		19.80		
8. Fuel, Oil & Lube	15.00	15.00	15.00	36.14	27.80	21.00	27.80	12.00	15.00		27.05		
9. Repairs - Machinery	20.80	20.80	20.80	40.56	31.20	20.80	31.20	8.00	20.80		31.45		
10. Repairs - Buildings	2.00	2.00	2.00	2.60	2.00	2.00	2.00	1.00	2.00		2.26		
11. Utilities & Misc. Expenses	9.00	9.00	9.00	16.25	12.50	12.50	12.50	2.25	9.00		12.96		
12. Custom Work/Special	5.00	5.00	5.00	19.50	15.00	10.00	15.00	0.00	5.00		13.48		
13. Operating Interest Paid	4.17	4.36	4.50	4.87	3.83	4.23	5.05	2.95	5.35		4.59		
14. Paid Labour & Benefits	17.88	14.40	6.96	23.09	17.76	28.08	18.00	18.00	18.00		20.01		
VARIABLE COSTS	**223.21**	**224.63**	**234.37**	**345.95**	**269.02**	**233.09**	**310.98**	**188.97**	**278.12**		**293.30**	**38,716**	**293,302**
(C) FIXED COSTS													
16. Land Taxes, Licenses/Insurance	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		9.00		
FIXED COSTS	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**	**9.00**		**9.00**	**1,188**	**9,000**
(D) CAPITAL COSTS													
17. Equipment & Bldg. Interest	32.32	32.32	32.32	32.32	32.32	32.32	32.32	32.32	32.32		32.32		
18. Building & Equipment Depreciation	75.21	75.21	75.21	75.21	75.21	75.21	75.21	75.21	75.21		75.21		
TOTAL CAPITAL COSTS	**107.53**	**107.53**	**107.53**	**107.53**	**107.53**	**107.53**	**107.53**	**107.53**	**107.53**		**107.53**	**14,194**	**107,527**
(E) CASH COSTS (B+C)	232.21	233.63	243.37	354.95	278.02	242.09	319.98	197.97	287.12		302.30	39,904	302,302
(F) TOTAL PRODUCTION COSTS (B+C+D+I)	361.21	357.23	385.22	492.43	408.59	377.70	451.51	323.49	412.89		435.93	57,543	435,931
(G) GROSS MARGIN (A-E)	66.25	77.83	119.96	230.05	171.98	109.91	80.02	82.03	62.88		155.87	20,575	155,875
(H) ANNUAL CASH FLOW (A-B-C-D)	-41.28	-29.70	12.43	122.52	64.45	2.38	-27.51	-25.49	-44.65		48.33	6,379	48,329
(I) UNPAID FAMILY LABOUR (non-cash)	21.48	16.08	34.32	29.95	23.04	28.08	24.00	18.00	18.24		26.10	3,445	26,102
(J) MEASURES OF FARM PROFITABILITY													
a. Return to Capital (A-B-C-I)	44.77	61.75	85.64	200.09	148.94	81.83	56.02	64.03	44.64		129.75	17,127	129,753
b. Percent Return to Capital	2.4%	3.3%	4.5%	10.6%	7.9%	4.3%	3.0%	3.4%	2.4%		6.9%	6.9%	6.9%
c. Return to Equity (A-B-C-D-I)	-62.76	-45.78	-21.89	92.57	41.41	-25.70	-51.51	-43.49	-62.89		22.23	2,934	22,227
d. Family Income (A-B-C-D)	-41.28	-29.70	12.43	122.52	64.45	2.38	-27.51	-25.49	-44.65		48.33	6,379	48,329

BACKGROUND DATA:

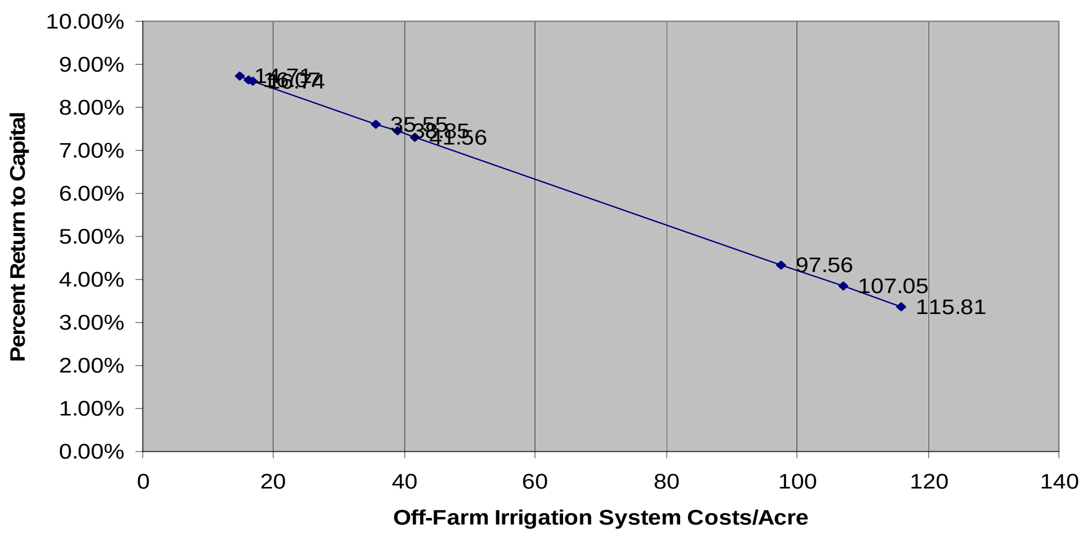
	Feed Barley	HRS Wheat	SWS Wheat	Alfalfa 2-cut	Alfalfa Hay	Barley Silage	Grass Hay	Tame Pasture	H.T. Canola	CROPS Weighted Average	132 ACRES	1000 ACRES**
INVESTMENT												
Land	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	79,200	600,000
Buildings	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	13,200	100,000
Machinery	375.00	375.00	375.00	375.00	375.00	375.00	375.00	375.00	375.00	375.00	49,500	375,000
Livestock												
Irrigation Equipment	817.72	817.72	817.72	817.72	817.72	817.72	817.72	817.72	817.72	817.72	107,939	817,720
TOTAL	1892.72	1892.72	1892.72	1892.72	1892.72	1892.72	1892.72	1892.72	1892.72	1892.72	249,839	1,892,720
LABOUR												
Hired Labour (hours)	1.49	1.20	0.58	1.92	1.48	2.34	1.50	1.50	1.50	1.67	220	1,667
Unpaid Labour (hours)	1.79	1.34	2.86	2.50	1.92	2.34	2.00	1.50	1.52	2.18	287	2,175
Total Labour (hrs./acre/yr.)	3.28	2.54	3.44	4.42	3.40	4.68	3.50	3.00	3.02	3.84	507	3,843
Rate/Hour	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00			

Straw/Aftermath Yield (tonnes)	2.57	1.76	2.17	0.00	0.00	0.00	0.00	0.00	0.00
Market Price ($/tonne)	20.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00

* For sources and methodological details, see Accompanying Footnotes, Attachment A-4.

** Assuming no economies of scale.

Figure 2.4. PERCENT RETURN TO CAPITAL FOR DIFFERENT OFF-FARM IRRIGATION SYSTEM COSTS/ACRE/YEAR



The important differences are with respect to the alternative Rate Schedules (the three very distinct data clusters); not the much smaller differences which would arise between Scenarios 1, 2, or 3.

Figure 2.3 illustrates how, with irrigation, the projected return to equity and family income would gradually decline as annual off-farm system O&M costs increased. At, say, \$15/acre/year (Rate Schedule #3), family income is projected to be about \$83/acre/year. At, say, \$38/acre/year (Rate Schedule #2), family income would likely drop to about \$60/acre/year. And at, say, \$100/acre/year (Rate Schedule #1), family income would probably become negative. At the same time, as annual off-farm O&M costs increased, the expected rate-of-return to farm capital would, predictably, also decline. (Figure 2.4) For Rate Schedule #1, #2, and #3 this rate-of-return would likely be about 3 – 4%, 7 - 8%, 8 – 9 %/annum, respectively.

Given related cost, prices, and technologies, these data at least strongly suggest that if farmers were faced with Rate Schedule #1 it is very unlikely that irrigation (regardless of the Scenario) would be considered a viable on-farm development opportunity in M.D. of Acadia. At \$85/acre/year, dryland farmers are actually equally as well off just expanding their existing dryland operation (see below, Section 2.4.3). Conversely, Rate Schedule #3 (which is similar to existing Irrigation District gravity rates in southern Alberta) should be very feasible. The ambiguity is between \$15 and \$85 per acre/annum.

The precise “cut-off” point is unclear because the agronomic, financial and managerial characteristics of each farmer are unique. But our professional judgment would suggest that three criteria should generally be applicable:

1. If farmers can’t generate a family income of \$50,000/annum with 1000 acres of irrigation (i.e. \$50/acre/year), it’s probably not “worth it”. This household income level is already typical of the region and province (Table 4.1). And an

on-farm capital cost of about $1120/acre[8] (i.e. $1.1M for 1000 acres) is still a relatively large on-farm capital requirement to create about two family jobs.

2. If farmers can't generate a 5 – 6%/annum return to capital, this also suggests that they might want to invest elsewhere. Real long-term rates-of-return to agriculture (net of inflation) have been about 4%/annum. Nominal long-term interest rates are now about 6% per annum. (Section 3.1.2)

3. Existing "water rates" for gravity supplies in Irrigation Districts in S. Alberta should serve as a "floor price." This average rate is presently about $17.60/acre/year.

Employing these criteria would at least strongly suggest that an annual off-farm system cost of about **$50/acre/year would likely be a potential maximum.** At $50/acre/year, the projected annual per-acre return to equity is $22/acre; the projected annual family income per acre is $48/acre; and the return-to-capital is 6.9 percent/annum. Thus, it is our professional judgment that between $18/acre per year and $50/acre/year, M.D. of Acadia farmers might be quite interested whereas between $50/acre/year and $85 very few (if any) M.D. of Acadia farmers would likely be interested. This is in addition to the annual on-farm irrigation cost of about $46/acre/year.

2.4 Irrigation versus Dryland

From Tables 2.3 and 2.6, the structural characteristics and measures of profitability for both existing dryland crop production and projected irrigated crop production can be compared. This general summary is provided in Table 2.7.

2.4.1 Structural Characteristics

Irrigation would radically change input use, capital requirements, labour requirements, and overall production levels. ($/acre) Revenues and cash costs would both likely increase about four-fold while total production costs would be expected to increase about 3.6 times. At the same time, irrigation is much more capital and labour intensive. Capital requirements would be expected to increase about 7.5 times (and the annual capital costs about 5.4X) while labour requirements would probably increase about 3.1 times. These comparisons are summarized following.

	Variable	Dryland	Irrigation	Ratio Irrig./Dryland
A	Gross Annual Revenue/Acre	$114	$458	4.0
B	Variable Costs/Acre	$86	$293	3.4
C	Fixed Costs/Acre	$4	$9	2.25
D	Capital Costs/Acre	$20	$108	5.4
E	Cash Costs (B+C)	$90	$302	3.4
F	Total Production Costs (B+C+D+I)	$122	$436	3.6
	Capital (excluding land)	$173	$1,293	7.5
	Labour (hired + unpaid)	1.25	3.84	3.1

[8] Average on-farm irrigation equipment cost = $818/acre; additional machinery = $302/acre.

Table 2.7. Changes in Revenue, Costs, Capital-Labour Requirements, and Farm Profitability, Irrigation versus Dryland — 2004-05$ per acre

I T E M	DRYLAND			IRRIGATION*			DIFFERENCE		
	CROPS, Weighted Average, ONE ACRE	132 ACRES	1000 ACRES	CROPS, Weighted Average, ONE ACRE	132 ACRES	1000 ACRES	CROPS, Weighted Average, ONE ACRE	132 ACRES	1000 ACRES
	1	2	3	4	5	6	7	8	9
A. GROSS REVENUE	**113.82**	15024	113820	**458.16**	60477	458158	**344**	45453	344338
B. VARIABLE COSTS	**86.20**	11378	86200	**293.30**	38716	293302	**207**	27337	207102
C. FIXED COSTS	**4.00**	528	4000	**9.00**	1188	9000	**5**	660	5000
D. TOTAL CAPITAL COSTS	**20.03**	2643	20025	**107.53**	14194	107527	**88**	11550	87502
E. CASH COSTS (B+C)	**90.20**	11906	90200	**302.30**	39904	302302	**212**	27997	212102
F. TOTAL PRODUCTION COSTS (B+C+D+I)	**121.93**	16094	121925	**435.93**	57543	435931	**314**	41449	314006
G. GROSS MARGIN (A-E)	**23.62**	3118	23620	**155.87**	20575	155875	**132**	17458	132255
H. ANNUAL CASH FLOW (A-B-C-D)	**3.59**	475	3595	**48.33**	6379	48329	**45**	5905	44734
I. UNPAID FAMILY LABOUR (non-cash)	**11.70**	1544	11700	**26.10**	3445	26102	**14**	1901	14402
(J) MEASURES OF FARM PROFITABILITY									
a. Return to Capital (A-B-C-I)	**11.92**	1573	11920	**129.75**	17127	129753	**118**	15554	117833
b. Percent Return to Capital	**2.6%**	2.6%	2.6%	**6.9%**	6.9%	6.9%	**4.3%**	4.3%	4.3%
c. Return to Equity (A-B-C-D-I)	**-8.11**	-892	-8105	**22.23**	-892	22227	**30**	0	30332
d. Family Income (A-B-C-D)	**3.59**	655	3595	**48.33**	655	48329	**45**	0	44734

BACKGROUND DATA:

INVESTMENT									
Land	**292.00**	38544	292000	**600.00**	79200	600000	**308**	40656	308000
Buildings	**32.00**	4224	32000	**100.00**	13200	100000	**68**	8976	68000
Machinery	**141.00**	18612	141000	**375.00**	49500	375000	**234**	30888	234000
Livestock									
Irrigation Equipment				**817.72**	107939	817720	**818**	107939	817720
TOTAL	**465.00**	61380	465000	**1892.72**	249839	1892720	**1428**	188459	1427720
LABOUR									
Hired Labour (hours)	**0.27**	36	270	**1.67**	220	1667	**1.4**	184	1398
Unpaid Labour (hours)	**0.98**	129	976	**2.18**	287	2175	**1.2**	158	1199
Total Labour (hrs./acre/yr.)	**1.25**	164	1246	**3.84**	507	3843	**2.6**	343	2596

* Assumes the annual on-farm irrigation cost is $46/acre and the annual off-farm system cost is $50/acre.

2.4.2 Measures of Profitability

The relative measures of farm profitability further underline how much irrigation would mean to the farming community in the M.D. of Acadia. The specific measures considered are: 1) gross margin; 2) return to capital; 3) return to equity ("profit"); and 4) family income (annual cash flow). ($/acre)

Whereas revenues and costs per acre would tend to climb 3 to 4 times (see above), the gross margin is projected to increase 6.5 times. The dollar return to capital invested could climb 10.8 times, as well as increase the annual rate-of-return to capital by about 4 percentage points.

Perhaps the two most significant measures of profitability relate to the return to equity ("profit") and family income ("cash flow"). Average annual profits would be expected to climb from a negative $8 per acre per year to a very positive $22 per acre per year. Even more impressively, farm family income would be expected to climb from a relatively low $4/acre/year to $48/acre/year. With 1000 acres of dryland, family income is a meager $4,000/year whereas with 1000 acres of irrigation, family income is $48,000/year. These per-acre comparisons are summarized following.

Measure	Dryland	Irrigation	Ratio Irrig./Dryland
Gross Margin (A-E)	$24	$156	6.5
Return to Investment $	$12	$130	10.8
Return to Investment %	2.6%	6.9%	2.7
Return to Equity ("Profit")	($8.11)	$22	n/a
Family Income ("Cash Flow")	$4	$48	12.0

It bears repeating that these comparisons are made assuming that the annual off-farm system cost to farmers is $50/acre/year. If it was higher, these ratios would drop; if it was lower, these ratios would be higher.

2.4.3 Irrigation Adoption Rates

Finally, in the above context, could or would existing dryland farmers in the M.D. of Acadia adopt irrigation and, if so, how quickly and how successfully?

Successful irrigation development will largely depend upon the initiative of local farmers. Adoption rates are, therefore, highly dependent upon the following: (I) relative profitability; (ii) capacity to invest; (iii) social-structural attributes; and (iv) location vis-à-vis infrastructure and markets. Very briefly:

The preceding profitability analysis (Section 2.4.2) indicates that irrigation in the M.D. of Acadia should be much more profitable than existing dryland crop production. And perhaps even more importantly, productivity increases very significantly. Profit/acre (or return to equity) is projected to increase from an existing minus $8.11/acre/year to $22/acre/year while family income is projected to increase from about $4/acre/year to about $48/acre/year. Thus, the choice between developing 132 acres of irrigation for about $159,000 (LP pivot, Attachment A-3 + $302 for other capital) or buying another (say) 367 acres of dryland for a similar capital cost outlay[9] is fairly obvious, at least regarding how it would enhance farm family income:

Dryland	Irrigation
491 X \$(4) = \$1,763/yr.	132 X \$48 = +\$6,336/yr.

This assumes that the farmer pays annual off-farm O&M system costs of \$50/acre/year. The incentive to develop irrigation would be stronger if this annual cost was lower; weaker if this annual cost was higher.[10] Adoption rates would probably be very low at \$75/acre/year; very high at \$25/acre/year.

At the same time, there should be considerable capacity to invest in irrigation equipment. Many project-area farmers are long-established dryland farmers with very low debt/equity ratios. The market value of a typical 2500 acre dryland farm is now about \$1.3 million[11], compared to the cost of a new 132 acre LP centre pivot (plus related machinery) of about \$159,000. Low-interest long-term credit is also now readily accessible through AAFC, FCC, credit unions, and commercial banks. Moreover, having successfully survived the Dirty Thirties and numerous adversities thereafter, most remaining M.D. of Acadia farm families are also very good farm managers; particularly with respect to risk management.

Yet another factor which may encourage existing dryland farmers to adopt irrigation is the realization that it is increasingly difficult to profitably produce traditional non-differentiated bulk commodities for the export market. Flat product prices and increasing unit costs continue to generate a long-term “cost-price squeeze”. Pessimism about the future of traditional dryland agricultural production in the agricultural community is increasingly pervasive.

On the other hand, some social-cultural conditions may act as a constraint. The average age of farmers’ (throughout Alberta) is now 49 years and he/she may now be thinking more about “getting out” than expanding. An older (sometimes risk-averse) dryland farmer may simply not want to become an irrigation farmer. Experience and “know-how” with irrigation in the area is also very limited. There are only about 1200 acres of existing irrigation in M.D. of Acadia and most existing irrigation is located 100+ kilometers away. Irrigation requires both more management skills and different production-marketing skills. Farmers around Taber-Bow Island (e.g.) “think” irrigation; farmers around Acadia Valley and Empress generally don’t –at least not yet.

The distance from markets may also serve as a deterrent to irrigation development; particularly with respect to specialty crop development. Grain (with elevator consolidation and rail line abandonment) is now generally hauled by truck to Oyen, Medicine Hat or Brooks. Livestock is generally sold at Brooks or High River. All potential specialty crop processing is equally remote, e.g. potato processing in the Taber-Lethbridge area.

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[9] Estimated as follows: \$159,000/\$324 per acre of dryland = 491 acres of additional dryland.

[10] These two investment options (dryland and irrigation) generate an equivalent annual income when the annual off-farm O&M cost is \$85/acre. At this cost, therefore, it is safe to say there would probably be virtually no interest in irrigation.

[11] Based on the following: land and bldgs. \$324/acre, machinery \$141/acre, and livestock \$55/acre, total \$520/acre.

Still, with strong farmer-support, M.D. of Acadia has financed two irrigation feasibility studies in the last two decades (1987 and 2005) and this, in itself, suggests that on-farm irrigation will likely be adopted at a rate not unlike that of other irrigation developments in the province if the farmers' contribution to annual off-farm O&M costs is also fairly similar.[12] Our best estimate is about 3,300 acres per year until project maturity. This would require the installation of about 25 centre pivots per year. [13]

2.5 Final Note

It should be re-emphasized that the above irrigation-dryland comparison is, at best, only generally indicative of the "real world". In particular:

1. Existing dryland farmers actually have a number of ways to avoid undue risk and "make a living" which are not fully reflected in the foregoing. These include:
    a. Very low debt/equity ratios (typical of older, long-established grain farmers)
    b. Comparatively low real land costs (perhaps purchased decades ago). Rates of return to capital, based on real costs, would be higher.
    c. Little use of borrowed operating capital, which decreases realized credit costs.
    d. Use of summerfallow. This is a revenue deferral strategy which decreases annual input expenditure requirements. Summerfallow also preserves some moisture for the following crop. This reduces both cash flow requirements and risk.
    e. Make extensive use of AFSC Crop Insurance and other government programs which include a public contribution, e.g. GRIP, NISA, CAIS, etc..
    f. Diversified income sources, which also reduces income variability. This includes, in particular, off-farm employment by various farm family members. On average, earnings presently make up 78% of M.D. of Acadia incomes while government transfers (pensions, etc.) make up 16% and other sources (esp. off-farm investments) make up 6.5 percent.[14]
    g. On-farm "processing" to capture more value-added (i.e. income) for the farm operation. The most obvious example is complimentary on-farm livestock production.
    h. Returns-to-scale and market power. Up to a certain point, increasingly large farms reduce unit costs-of-production. With some market power, larger farms may also be able to secure slightly lower input prices and slightly higher product prices.

[12] The average "water rate" in Irrigation Districts in Southern Alberta (for gravity systems) is now $17.60/acre/year. Systems with pumping generally have higher rates. (MPE Engineering)
[13] This is similar to the rate of development expected in the earlier (1987) study.
[14] Statistics Canada, **Community Profiles 2001, Acadia Valley No 34,** Ottawa. www12.statcan.ca/English/profil01/Details

i. Above-average production or marketing characteristics. This includes growing a more profitable crop mix, “tweaking” crop production technologies, and extracting above-average prices from the market place.

2. Irrigation farmers would be equally adept and real world “refinements” would include the following:

   a. Additional on-farm activities to further enhance value-added (i.e. incomes), especially additional livestock production.
   b. Mixed irrigation-dryland combinations. This can help circumvent capital & labour constraints.
   c. Diversified income sources, similar to dryland farmers. (see above)
   d. Also similar to dryland farmers, above-average production or marketing characteristics. This again includes growing a more profitable crop mix, “tweaking” crop production technologies, and extracting above-average prices from the market place. (as above).

3. PROVINCIAL BENEFIT-COST ANALYSIS

3.1 Methodology

3.1.1 Evaluation Criteria

A provincial discounted cash flow analysis compares quantifiable projected benefits with quantifiable projected costs into the foreseeable future. This “benefit-cost analysis” helps determine if a proposed investment would or would not use Alberta resources efficiently.

Four criteria are utilized to gauge how (socially) profitable a proposed investment would be:

CRITERIA	DESCRIPTION
1. Internal Rate of Return (IRR)	That interest (i.e. discount) rate where the cumulative discounted benefits are exactly equal to the cumulative discounted costs over a given time period. Preferred by many (e.g. World Bank) because it avoids pre-determining what the most appropriate social discount (i.e. interest) rate should be. However, politically, this still requires establishing a minimum acceptable rate of return.
2. Benefit-Cost Ratio (B/C Ratio)	The ratio of cumulative discounted benefits to cumulative discounted costs over a given time period for a particular interest rate. Different methodologies can generate different ratios <> unity.[15] No units. Measures efficiency (“bang for the buck”) but not scale.
3. Net Present Value (NPV) of Incremental Socio-Economic Benefits	Cumulative discounted benefits minus cumulative discounted costs over a given time period for a particular interest rate. Measures the incremental cumulative absolute dollar value over time. Probably the best economic measure when selecting between Investment A and Investment B if both opportunities have a B/C ratio > 1.
4. Pay-back Period	The number of years required to recover the capital and on-going discounted cost of a proposed investment.

To be considered economically feasible, the IRR must exceed a politically prescribed minimum annual rate-of-return. At the same time, for a specified interest (or discount) rate the B/C ratio must be greater than one, the NPV must be positive, and the pay-back period should not exceed a maximum number of years approximated by 70/interest rate, e.g. at 4% $\Rightarrow$ 18 years. For a single investment proposal and a desired social rate of return on the proposed investment, all of these criteria generally provide the economic analyst with the same policy prescription, i.e. go or no-go.

[15] Note, in particular, utilizing gross incremental revenues (GR) and gross incremental costs (GC) in the numerator and denominator, respectively, compared to total investment costs (TIC) also in the numerator) is not equivalent to utilizing net incremental benefits (NIB) in the numerator and total investment costs in the denominator. E.g. GR = 120, GC = 70, NIB =50, and TIC = 30. Methodology #1 = 120/(70+30) = 1.2. Methodology #2 = 50/30 = 1.7. These two procedures only generate the same ratio when B/C = 1. E.g. GR = 120, GC=90, NIB = 30, and TIC = 30. Methodology #1 = 120/(90+30) = 1.0. Methodology #2 = 30/30 = 1.0. This report utilizes Methodology #1.

A simple illustration, Table 3.1, is instructive: (interest rate = 4%)

Table 3.1. Illustrative Discounted Cash Flow Analysis

Year	COSTS		BENEFITS		Interest=4%	Actual B-C	Cumulative
	Actual	Discounted	Actual	Discounted	Factor		Discounted B-C
	1	2	3	4	5	6	7
1	65	62.5	0	0.0	0.9615	-62.5	-62.5
2	65	60.1	0	0.0	0.9246	-60.1	-122.6
3	10	8.9	10	8.9	0.889	0.0	-122.6
4	10	8.5	20	17.1	0.8548	8.5	-114.0
5	10	8.2	30	24.7	0.8219	16.4	-97.6
6	10	7.9	40	31.6	0.7903	23.7	-73.9
7	10	7.6	50	38.0	0.7599	30.4	-43.5
8	10	7.3	50	36.5	0.7307	29.2	-14.3
9	10	7.0	50	35.1	0.7026	28.1	13.8
10	10	6.8	50	33.8	0.6756	27.0	40.9
Sum Total	C=	**184.8**	B=	**225.7**			
IRR*						5%	
B/C	equals 225.7/184.8		1.22				
NPV	equals 225.7-184.8		40.9				
Pay Period							8.5 years

* That discount rate where B=C.

Discounting future cash flows allows us to compare “apples to apples”. The value of a dollar paid or received in five years is not the same as a value of a dollar paid or received today.

These are all efficiency criteria which entirely ignore equity considerations**.** The rationale for this is that if NPV>0 and B/C>1 for the province, then it should always be possible for those who gain from the implementation of a particular investment to compensate those who lose (if, indeed, there are losers) from project implementation. At the same time, this simple calculus does not consider (without further refinements) the possibility that a dollar may be worth more to a relatively poor community than to a relatively wealthy community.

These efficiency criteria also ignore **who** actually pays.

This provincial accounting stance is not the same as a regional impact analysis (Sub-Section 4 following). The regional impact analysis (following) fully considers both the direct and indirect impact of all regional activities generated by the proposed project on the local economy.

3.1.2 Methodological Procedures

a. Standards & Precedents

There are well-established and widely-used standards and procedures for conducting a cash flow analysis of potential investment opportunities. The most recent "handbook" is published by the World Bank and entitled **Economic Analysis of Investment Operations: Analytical Tools and Practical Applications (2001)**.[16] The methodology employed in this report is generally consistent with that of the World Bank, as well as what has been utilized in three other recent water management studies in Alberta:

- Klohn Crippen, **Milk River Basin Preliminary Feasibility Study**, Alberta Environment, February 2004.
- Golder, **Meridian Dam Preliminary Feasibility Study,** Alberta Environment, February 2002.
- Alberta Environment, **Proposed Little Bow Project/Highwood Diversion Plan, Environmental Impact Assessment, Vols. 4 (Socio-Economic Assessment) and 9, appendix P (Economic and Socio-Economic Assessment)**, Edmonton, 1995.

b. Time Frame

The relevant time-frame depends upon how much society discounts the future, i.e. the real interest (or discount) rate. A lower discount rate means that a longer time-frame should be considered.

The significant economic life of a project is the time required such that more than 90 percent of the cumulative present value of the benefits and costs are fully considered. The time frame utilized following is the construction period plus fifty years. For additional accuracy, end-period residual values are also incorporated into the analysis.

c. Constant Prices

All costs and prices are presented in terms of current 2004-05 dollars. This assumes that relative prices and costs will always remain the same. Most importantly, it implicitly assumes that the agricultural gross margin also remains constant over 50+ years; that technology and/or economies-of-scale will allow the gross agricultural margin to remain the same as in 2004-05. Despite its inherent limitations, this assumption is considered more reasonable than speculating about future inflation rates and future technological change.

d. Social Discount Rate

The real discount rate (exclusive of inflation) used to discount benefit and cost streams or the rate used as a cutoff point is crucial. Ideally, it should reflect not only the likely returns to funds in their best alternative use (i.e. the opportunity cost of capital or investment rate of interest) but also the marginal rate at which savers willingly save.

[16] Also see: J. Price Gittinger, **Economic Analysis of Agricultural Projects**, 2nd edition, World Bank, Washington, D. C.,1982; Asian Development Bank, **Guidelines for the Economic Analysis of Projects**, Manila, 1997; and Bergmann, H., and J. Boussard, **Guide to the Economic Evaluation of Irrigation Projects,** OECD, Paris, 1976. There are literally dozens of academic references.

These calculations are complex and earlier studies on this subject are of limited use.[17] Previous water management studies in Alberta, most of which have used a basic social discount rate of 5%/annum, also seem increasingly at odds with the "new reality". Real short-term interest rates in Canada, USA, and Europe are now negative (see illustration) and even 10 to 30 year Canadian government bonds are only yielding a real rate of return of perhaps 3 percent/annum.[18] Environmentalists have also long argued that for environmental amenities no social discount rate should be employed.[19]

Source: **The Economist**, October 2-8, 2004.

This ambiguity is a principal reason for making greater use of the Internal Rate of Return criteria in the analysis following. Decision-makers, rather than researchers, can then decide which B/C ratio best reflects the real social discount rate in Alberta today.

Where required, the real social discount rate chosen as the base rate in this appraisal is 4 percent per annum.

e. Market Price Adjustments

All costs and prices employed in the analysis are supposed to be un-distorted international market prices. These costs and prices exclude taxes, subsidies, transfer payments, exchange rate distortions, trade distortions, and any other market distortion, e.g. "sticky" labour rates. Un-distorted costs and prices are what economists refer to as "economic" prices (as opposed to financial prices) or "shadow prices".

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[17] See, in particular: Reuber, G. L., and R. J. Wonnacott, **The Cost of Capital in Canada—with Special Reference to Public Development of the Columbia River,** Resources for the Future, Washington, D. C., 1961. Also see: Jenkins, G. P., "The Measurement of Rates of Return and Taxation from Private Capital in Canada", in: **Benefit Cost and Policy Analysis,** edited by A. C. Harberger, **et.al.,** Chicago, Aldine Publishing, 1972. Of particular interest is the fact that Jenkins calculated that the real rate of return for the agricultural sector to be 2.83 percent per annum.

[18] Current nominal yields (**National Post,** February 23, 2005) for Canada 10-year bonds is 4.23%; for 30 year bonds 4.73%. Net of projected inflation of 1.5%/year, these rates, in real terms, are 2.73%/year and 3.23%/year, respectively.

[19] The original research (on optimal forest depletion) was done by Paul Samuelson and, later, numerous "environmental economists" further enriched the debate.

There are numerous cost and price distortions in the Alberta economy, particularly in agriculture. Examples include the hidden taxes in fertilizer and fuel and the international grain price distortions largely attributed to US and European export subsidies.

The present economic analysis utilizes long-term average farm-gate product prices as representative of free market prices (Attachment A-1). The only price adjustment made is with respect to AFSC crop insurance premiums. The Canada-Alberta governments pay about 60% of the real premium, thus increasing the farm premium (Table 2.3) to society by about 150 percent. This effectively reduces the real profitability of highly variable dryland production in Alberta and elsewhere.

f. Scheduling

The annual incidence of costs and benefits must also be carefully determined. Estimated construction costs are scheduled over Years 1-3, with irrigation beginning in Year 4. The reservoir will be filled in Year 3. After construction, all initial and re-occurring on-farm capital costs are linked to irrigation development rates and the expected life-span of various capital items. Annual operating costs and revenue projections are similarly linked to irrigation development levels.

3.2 Incremental Costs

Five incremental costs have been identified and are described following.

Incremental Costs
3.2.1. Construction Costs & O&M
3.2.2 On-Farm Irrigation Equipment Costs
3.2.3 On-Farm Supplementary Equip. Costs
3.2.4 Annual Δ Crop Production Costs
3.2.5 Annual Δ Livestock Production Costs

3.2.1 <u>Construction Capital & O&M Costs</u>

There are three development scenarios:
- Scenario 1: 5,500 ha. (13,600 acres)
- Scenario 2: 8,900 ha. (22,000 acres)
- Scenario 3: 10,850 ha. (27,000 acres)

Projected capital costs and related annual O&M costs for the respective developments are summarized in Table 3.2. The design-construction period is estimated to be three years. A detailed breakdown of all these costs is provided in Section 9.0 of the main report.

Table 3.2. Summary of Capital Costs, Years 1-3 2005 $

Item	Scenario 1	Scenario 2	Scenario 3
Diversion and Supply:	$12,020,000	$16,630,000	$16,630,000
Storage Reservoir:	$10,830,000	$12,750,000	$14,820,000
Distribution System:	$31,730,000	$49,730,000	$64,660,000
Contingencies (25%)	$9,490,000	$14,130,000	$17,160,000
Engineering Design, Geotechnical, Related	$7,120,000	$8,480,000	$10,300,000
TOTAL CAPITAL SYSTEM COST	**$54,600,000**	**$79,100,000**	**$96,100,000**
Total Irrigated Area: (ha), fully developed	5500	8900	10850
Capital Cost per hectare	$9,927	$8,888	$8,857
Capital Cost per irrigated acre	$4,017	$3,597	$3,584
3-Year Expenditure Pattern: /year	**$18,200,000**	**$26,366,667**	**$32,033,333**

Source: MPE estimates, Section 9.0.

Subsequent O&M costs are expected to average about 3 percent of total capital costs per annum. Main diversion pumping costs are expected to make up about 2/3rds of this total. (Table 3.3)

Table 3.3. Annual Operation & Maintenance Costs, M.D. of Acadia $2005

Item	Scenario 1	Scenario 2	Scenario 3
Main Pumpstation at Red Deer River-Energy*	$1,111,000	$1,705,000	$1,934,000
Pumpstation, Pipeline, & Reservoir**	$235,400	$295,400	$299,700
Distribution System***	$204,000	$330,000	$405,000
Municipal Pumpstation*	$98,600	$98,600	$217,300
TOTAL	**$1,650,000**	**$2,430,000**	**$2,860,000**
Total/Acre/Year	$121.32	$110.45	$105.93

* O&M + Energy Surcharge + $.075/kWh. **2.5% of pumpstation capital cost; 0.25% of pipeline capital cost and 0.50% of reservoir capital cost. ***$15/acre.

Source: MPE estimates, Section 9.0.

It is expected the new reservoir on Kennedy Coulee tributary will be filled in Year 3 and on-farm irrigation development will commence in Year 4.

3.2.2 On-Farm Irrigation Equipment Costs

Associated on-farm irrigation development costs include the purchase and annual operation of an irrigation system and (if electrically-driven) access to three-phase power. Based on AAFRD-IDM modeling (see elsewhere), equipment composition is expected to approximately as follows: low pressure centre pivots 50%; high pressure centre pivots 35%; and wheel rolls/hand 15 percent. Centre pivots serve 132 acres. The weighted average cost of this new equipment (including a 3-phase power line) is estimated in Table 3.4 to amount to about $818/acre. ($2,021/hectare).

Table 3.4. On-Farm Capital Costs of Irrigation Equipment ($2004-05)

Type	HAND	WHEEL 2	WHEEL 4	Pivot HP	Pivot LP
Percent	**5.0%**	**5.0%**	**5.0%**	**35.0%**	**50.0%**
COST SUB-TOTAL	36630	43330	56030	89230	93510
3-Phase Electricity	25000	25000	25000	25000	25000
TOTAL	61630	68330	81030	114230	118510
Area/Unit (Acres)	160	160	160	132	132
TOTAL/ACRE	$ 385	$427	$506	$865	$898
Total/Hectare	$ 952	$ 1,055	$1,251	$2,138	$ 2,218
WEIGHTED AV./ACRE					**$ 817.72**
Weighted Av./Ha.					$ 2,020.58

Source: For further details, see Attachment A-3.

The purchase of used irrigation equipment would reduce realized farm costs. A sub-optimal irrigation development configuration would increase estimated 3-phase electricity installation costs.

The corresponding annual operating and maintenance cost is estimated to amount to about $46/acre (or $114/hectare). This is based on an average annual water application rate of 393 mm (15.5”). These costs are incorporated into the annual crop budgets estimated in Section 3.2.4 following.

On-farm irrigation equipment costs would be incurred when the respective irrigation acreages were actually developed.

3.2.3 Supplementary On-Farm Building-Machinery Costs

Much more intensive crop-livestock production will also require more related on-farm buildings and machinery. Based on numerous AAFRD-CRD studies, as well as special Census of Agriculture calculations, these order-of-magnitude estimates are:[20] (per acre)

	Machinery	Buildings	Total
Irrigation	$375	$100	$475
Dryland	141	32	173
Difference	$234	$ 68	**$302/acre**

This is in addition to the $818/acre required for irrigation equipment as detailed in Section 3.2.2 above.

These supplemental building and machinery costs would also be incurred when the respective irrigation acreages were actually developed.

[20] CRD = Cost and Return Data. Earlier **Census of Agriculture** comparisons have also been made between dryland and irrigation “farms”. Building estimate = 10% of total land and building values.

3.2.4 Annual Incremental Crop Production Costs

Annual incremental crop production costs are based on a weighted average of individual crop budgets for both dryland and irrigation (Sub-Section 2), adjusting financial costs (Table 2.3) to socio-economic (or "shadow") costs. The only adjustment made for this analysis is with respect to AFSC crop insurance premiums for dryland where the financial cost is estimated to average $7.75/acre and the economic cost is $ 19.37/acre.

In total, operating expenses (i.e. variable costs) for enhanced crop production are projected to increase from $101/acre to $251/acre, a difference of $149/acre (or $369/ha). (Table 3.5). Irrigation production cost estimates include on-farm pumping (i.e. energy and O&M) costs of about $46/acre (Attachment A-6).

Table 3.5. Annual Incremental Crop Production Costs, M.D. of Acadia **$2004-05**

Item	Irrigation	Dryland	Difference	
	$/Acre	**$/Acre**	**$/Acre**	**$/Ha.**
Gross Revenue	458.16	113.82	344.34	850.51
Costs-of-Production*	**250.61**	**101.18**	**149.43**	**369.09**
Gross Margin	207.55	12.64	194.91	481.42

Source: Attachment A-7.

The total annual incremental crop production cost is linked to the total area irrigated.

3.2.5 Annual Incremental Livestock Production Costs

In southern Alberta, livestock operations dependent upon irrigation for feedstuffs are often considered their most important "specialty crop". Livestock densities in Lethbridge County 26, for example, are presently about 8 or 9 times those of Acadia MD #34.[21] Based on changes to the production of Digestable Crude Protein, we estimate irrigation in the M.D. of Acadia project area would support 12.4 times as many animal units (AU) as currently maintained on the basis of existing dryland crop productivities (Attachments A-5 and A-6).This includes both on-farm vertically integrated production and regional intra-farm production dependencies.

For simplicity, annual incremental livestock cost estimates for the present study are calculated on the basis of an assumed 25 percent incremental value-added (or gross margin) that can be secured from the increased production of feedstuffs in the region.[22] As an average value-added for the entire livestock industry (beef, pork, poultry, etc.), this is a relatively low value-added estimate vis-à-vis crops.

Inflating the potential gross margin (or value added = VA) of all feedstuffs by 25 percent generates a weighted average VA value of $49.47 and $2.40 for irrigation and dryland,

[21] Approximate. Based on the **Census of Agriculture, 2001.**
[22] This methodology has been developed and refined in numerous prior "irrigation" studies: Oldman River, Milk River, Meridian, Highwood-Little Bow, Clear Lake, Little Bow, Pine Coulee, and others. The alternative to this is the use of multiple livestock "models" which contain still more assumptions about the structure, conduct, and performance of these particular enterprises. See, for example: Heikkila, R., **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**, AAFRD, Edmonton, September 1988.

respectively (Attachments A-5, A-6, and A-7).[23] This increase arises because of both crop composition changes and crop yield changes. This translates into about 19% of the total projected incremental value-added of irrigated agriculture. Thus, with costs-of-production expected to be 3 times value-added, the respective cost-of-production estimates for livestock are $144.27 and $7.21 for irrigation and dryland, respectively.[24] And this, in turn, implies an annual incremental livestock production cost of $137.06/acre (or $338.53/hectare). (Table 3.6) This is a regional on-farm potential.

Table 3.6. Annual Incremental Livestock Production Costs, M.D. of Acadia $2004

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	192.36	9.62	182.74	451.36
Costs-of-Production	**144.27**	**7.21**	**137.06**	**338.53**
Gross Margin	48.09	2.41	45.68	112.83

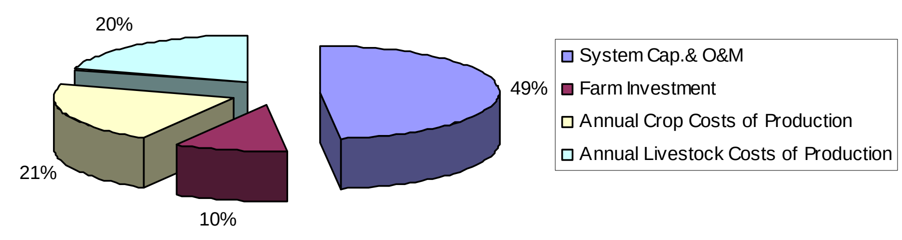
Source: Attachment A-7.

The total annual incremental livestock production cost is then based on the total area irrigated.

3.2.6 Cost Summary

In terms of their relative importance, over a 53 year period, real costs for Scenario #3 (and #1and #2 are very similar) are divided approximately as follows: system capital and O&M 49%; farm capital requirements 10%; annual crop costs of production 21%; and annual livestock costs of production 20 percent. (Figure 3.1)

Figure 3.1. SCENARIO 3 - RELATIVE REAL COSTS @4% DISCOUNT RATE



[23] A 25% increase in the gross margin is roughly equivalent to a 10% increase in crop prices.
[24] Logically, if VA = 25%, variable costs must be 3X as large and revenue 4X as large.

3.3 Incremental Benefits

Three net benefits are particularly important and are described following.

Incremental Benefits
3.3.1 Annual Δ Crop Revenue
3.3.2 Annual Δ Livestock Revenue
3.3.3 Other Incremental Benefits (livestock water, domestic water, recreation)

3.3.1 Annual Incremental Crop Revenue

Annual incremental crop revenue estimates are based on a weighted average of individual crop budgets for both dryland and irrigation (Sub-Section 2).

In total, annual crop revenue with enhanced crop production is projected to increase from $114/acre to $458/acre, a difference of $344/acre (or $851/ha). (Table 3.7).

Table 3.7. Annual Incremental Crop Revenue, M.D. of Acadia **$2004-05**

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	**458.16**	**113.82**	**344.34**	**850.51**
Costs-of-Production*	250.61	101.18	149.43	369.09
Gross Margin	207.55	12.64	194.91	481.42

Source: Attachment A-7.

The total annual incremental crop revenue is dependent upon the total area irrigated.

3.3.2 Annual Incremental Livestock Revenue

Additional livestock production again includes (as per Section 3.2.5) both on-farm vertically integrated production and regional intra-farm production dependencies.

Similar to the corresponding incremental cost estimates (Section 3.2.5), annual incremental livestock revenue estimates for the present study are calculated on the basis of an assumed 25 percent incremental value-added (or gross margin) that can potentially be secured from the increased production of feedstuffs in the region.

As already noted (Section 3.2.5) inflating the potential gross margin (or value added = VA) of all feedstuffs by 25 percent generates a weighted average VA of $49.47 and $2.40 for irrigation and dryland, respectively (Attachments A-5, A-6, and A-7).[25] Thus, since revenues are expected to be 4 times value-added, the respective gross revenue estimates are $192.36 and $9.62 for irrigation and dryland, respectively.[26] And this, in turn, implies an annual incremental livestock revenue of $182.74/acre (or $451.36/hectare). (Table 3.8) Once again, this is a regional on-farm potential.

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[25] A 25% increase in the gross margin is roughly equivalent to a 10% increase in crop prices.
[26] Logically, if VA = 25%, variable costs must be 3X as large and revenue 4X as large.

Table 3.8. Annual Incremental Livestock Production Costs, M.D. of Acadia $2004

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	**192.36**	**9.62**	**182.74**	**451.36**
Costs-of-Production	144.27	7.21	137.06	338.53
Gross Margin	48.09	2.41	45.68	112.83

Source: Attachment A-7.

The total annual incremental livestock revenue is then based on the total area irrigated.

3.3.3 Other Incremental Benefits

Although this is primarily an "irrigation" project, there are a number of other benefits which should also be quantified, wherever possible. This serves two purposes: 1) it at least flags their potential existence; and 2) it at least provides some indication of their order-of-magnitude. Are they likely to represent 1% or 10% of direct net irrigation benefits?

The potential benefits of particular concern are:

- enhanced livestock water availability
- enhanced urban-rural domestic water access
- enhanced recreational amenities

3.3.3.1 *Livestock Water Availability*

Livestock require an ample and good quality water supply and existing water limitations have limited livestock expansion in the region, particularly intensive livestock operations (ILO's).[27] The proximity of water for irrigation would also make this supply available to ILO's.

It is estimated elsewhere that on the basis of enhanced livestock feed production, livestock numbers (n terms of animal units – AU) should eventually increase at least 10 fold. (Sections 3.2.5 and 3.3.2) This would mean, very approximately, that whereas there was previously about 0.1 AU per dryland acre, after irrigation was in place, there could be about 1 AU per acre; an increase of 0.9 AU/irrigated acre. This is based solely on the expected change in feed availability for the project area in question.

At the same time, the value of water for livestock varies widely, with a reported average value of $355 per dam^3 (220,000 gallons).[28] Similarly, it has been estimated that in the Special Areas the cost of filling a ½ million gallon dugout is about $750. This is equivalent to 0.15 cents per gallon or $330 per dam^3, almost an identical value. Thus, based on a gross AU water requirement of 10 gallons per day, the value of the water for the increased livestock on an annual per-acre basis would be equal to approximately 0.9 AU X 10 gal. X 365 days X 0.15 cents = **$4.93 per acre per annum.**

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[27] For details, see SAWSP Socio-Economic Study (draft), 2005.
[28] For details, see Marv Anderson & Associates, **Profile of Irrigation in the Highwood-Little Bow** (draft), Edmonton, January 2003, and related documents.

3.3.3.2 *Urban-Rural Potable Water Access*

It is not known to what extent the proximity to water for irrigation would allow nearby rural or urban households to also access this for domestic purposes and, thus, the economic analysis does not ascribe a dollar benefit to this water. At the same time, it should be noted that the unit value of this water (however much is extracted) could be assumed to be worth at least as much as it costs to use Henry Kroeger HKRWC pipeline water; about $960/dam^3 plus distribution costs, or approximately 0.4 cents per gallon.[29]

3.3.3.3. *Enhanced Recreational Amenities*

Recreation here includes, in particular, fishing, upland bird hunting, big game hunting, and non-consumptive recreation (camping, boating, bird-watching, etc.). How would these activities be impacted by the proposed “irrigation” project in question? This is unclear.

Nevertheless, there is ample evidence to indicate that increased biomass generally enhances the environment and wildlife habitat and this, in turn, enhances recreational opportunities in and around a new irrigation area.[30]

To put this anticipated benefit into context, we rely on recent research in the neighbouring Special Areas.[31] We then estimate that the annual M.D. of Acadia benefit (Scenario 3 at project maturity) would be about 20% as large as that of the proposed SAWSP project to the north. The resulting estimates are as follows:

Table 3.9. Estimated Value of Enhanced Recreation, M.D. of Acadia

Type of Recreation	Marginal Extra-Market Value*	20% SAWSP Total Person-Days	Total Annual Value
Fishing	20% of $23.50/day= $4.70	2,448	$11,500
Upland Bird Hunting	20% of $13.90/day= $2.78	2,091	$5,800
Big Game Hunting	20% of $15.00 = $3.00	11,500	$34,500
Non-Consumptive	20% of $8.05 = $1.61	16,040	$25,800
TOTAL			**$77,600**
Total/Acre Irrigated			**$2.87/acre**

- Extra-market value is the value over and above that which is actually paid. Marginal value is estimated to equal 20% of total extra-market value.

Source: Basic data from SAWSP **Socio-Economic Analysis** (draft), 2005.

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[29] HKRWC estimate from the SAWSP **Socio-Economic Report** (draft), 2005. Again, this is very similar to average water values typical of municipal and residential users elsewhere in Canada; about $1,220/dam^3 and $1,681/dam^3, respectively. Source: MAA, **Profile of Irrigation in the Highwood-Little Bow** and related documents.

[30] See, for example: AIPA, **Irrigation Impact Study: Accomplishments & Opportunities,** Vol. 7, UMA/AIPA, Lethbridge, May 1993.

[31] SAWSP, **Socio-Economic Report** (draft), 2005.

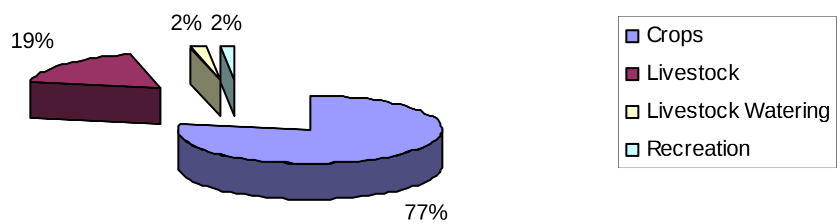
This is the current $2005 value which we anticipate will then increase (in real terms, net of inflation) at a rate of about 1.4 percent per year for the duration of the proposed project. This acknowledges that over time leisure will likely become increasingly important to the public.[32]

Although very approximate, this recreational benefit of (say) 2% of irrigation benefits is quite similar to prior research findings elsewhere in the province.[33]

3.3.4 Net Benefit Summary

In terms of their relative importance, over a 53 year period, real **net** benefits are divided approximately as follows: irrigated crops 77%; associated livestock operations 19%; livestock watering 2%; and recreation 2 percent. (Figure 3.2)

Figure 3.2. SCENARIO 3 - RELATIVE REAL NET BENEFITS @4% DISCOUNT RATE



3.4 Economic Assessment

A discounted cash flow analysis was conducted for each of the three on-stream development proposals:

- Scenario 1: 5,500 ha. (13,600 acres)
- Scenario 2: 8,900 ha. (22,000 acres)
- Scenario 3: 10,850 ha. (27,000 acres)

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[32] This methodology was first employed in the **Little Bow-Highwood Diversion Plan, Environmental Impact Assessment: Socio-Economic Assessment**, Vol. 4, Alberta Public Works/Golder, Calgary, 1995.

[33] McNaughton, R. B., **Irrigation Impact Study: Recreation, Vol. 3,** AIPA, Lethbridge, May 1993.

The methodology employed is detailed in 3.1 preceding. Estimated costs and projected benefits are all quantified in Sections 3.2 and 3.3, respectively. To further facilitate interpreting the respective simulations, Tables 3.10, 3.11, and 3.12 following, all of the basic data drawn from Sections 3.2 and 3.3 accompany the respective Tables.

Table 3.10. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 1 (13,600 acres) — $ Thousands 2004-05

	INCREMENTAL COSTS											INCREMENTAL BENEFITS								
Project Year	Project Capital+Eng-ineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreat-ion	Other Incre. Benefits	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	18200	0	0	0	0	0	0	0	0	0	**18200**	0	0	0	0	0	**0**	**-18200**		
2	18200	0	0	0	0	0	0	0	0	0	**18200**	0	0	0	0	0	**0**	**-18200**		
3	18200	0	1111	0	0	0	0	0	0	0	**19311**	0	0	0	0	0	**0**	**-19311**		
4	0	301	269.6	20.1	2514.4	996.6	129.8	341.6	452.3	0	**5025**	1136.3	603.0	16.3	9.5	0	**1765**	**-3260**	3300	3300
5	0	350	539.2	40.3	2514.4	996.6	259.7	683.2	904.6	0	**6288**	2272.6	1206.1	32.5	19.2	0	**3530**	**-2757**	6600	3300
6	0	400	808.7	60.4	2514.4	996.6	389.5	1024.8	1356.9	0	**7551**	3409.0	1809.1	48.8	29.2	0	**5296**	**-2255**	9900	3300
7	0	449	1078.3	80.6	2514.4	996.6	519.4	1366.5	1809.2	0	**8814**	4545.3	2412.2	65.1	39.5	0	**7062**	**-1752**	13200	3300
8	0	455	1111.0	83.0	304.8	120.8	535.1	1407.9	1864.0	0	**5882**	4683.0	2485.3	67.0	41.3	0	**7277**	**1395**	**13600**	400
9	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	41.8	0	**7277**	**1821**	13600	
10	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	42.4	0	**7278**	**1822**	13600	
11	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	43.0	0	**7278**	**1822**	13600	
12	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	43.6	0	**7279**	**1823**	13600	
13	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	44.2	0	**7280**	**1824**	13600	
14	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	44.9	0	**7280**	**1824**	13600	
15	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	45.5	0	**7281**	**1825**	13600	
16	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	46.1	0	**7281**	**1825**	13600	
17	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	46.8	0	**7282**	**1826**	13600	
18	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	47.4	0	**7283**	**1827**	13600	
19	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	48.1	0	**7283**	**1827**	13600	
20	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	48.8	0	**7284**	**1828**	13600	
21	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	49.4	0	**7285**	**1829**	13600	
22	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	50.1	0	**7285**	**1829**	13600	
23	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	50.8	0	**7286**	**1830**	13600	
24	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	51.5	0	**7287**	**834**	13600	
25	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	52.3	0	**7288**	**835**	13600	
26	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	53.0	0	**7288**	**836**	13600	
27	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	53.7	0	**7289**	**836**	13600	
28	0	455	1111.0	83.0	0	120.8	535.1	1407.9	1864.0	0	**5577**	4683.0	2485.3	67.0	54.5	0	**7290**	**1713**	13600	
29	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	**7970**	4683.0	2485.3	67.0	55.3	0	**7291**	**-680**	13600	
30	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	**7970**	4683.0	2485.3	67.0	56.0	0	**7291**	**-679**	13600	
31	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	**7970**	4683.0	2485.3	67.0	56.8	0	**7292**	**-678**	13600	
32	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	**7970**	4683.0	2485.3	67.0	57.6	0	**7293**	**-677**	13600	
33	0	455	1111.0	83.0	304.8	0	535.1	1407.9	1864.0	0	**5761**	4683.0	2485.3	67.0	58.4	0	**7294**	**1533**	13600	
34	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	59.2	0	**7295**	**1839**	13600	
35	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	60.1	0	**7295**	**1839**	13600	
36	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	60.9	0	**7296**	**1840**	13600	
37	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	61.8	0	**7297**	**1841**	13600	
38	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	62.6	0	**7298**	**1842**	13600	
39	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	63.5	0	**7299**	**1843**	13600	
40	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	64.4	0	**7300**	**1844**	13600	
41	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	65.3	0	**7301**	**1845**	13600	
42	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	66.2	0	**7302**	**1846**	13600	
43	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	67.1	0	**7302**	**1846**	13600	
44	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	68.1	0	**7303**	**851**	13600	
45	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	69.0	0	**7304**	**852**	13600	
46	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	70.0	0	**7305**	**853**	13600	
47	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	**6453**	4683.0	2485.3	67.0	71.0	0	**7306**	**854**	13600	
48	0	455	1111.0	83.0	0	120.8	535.1	1407.9	1864.0	0	**5577**	4683.0	2485.3	67.0	72.0	0	**7307**	**1731**	13600	
49	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	73.0	0	**7308**	**1852**	13600	
50	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	74.0	0	**7309**	**1853**	13600	
51	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	75.0	0	**7310**	**1854**	13600	
52	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	**5456**	4683.0	2485.3	67.0	76.1	0	**7311**	**1855**	13600	
53	-27300.01	455	1111.0	83.0	-463.26	-2582.1	535.1	1407.9	1864.0	0	**-24889**	4683.0	2485.3	67.0	77.1	0	**7312**	**32202**	13600	
PV 0%	27300	22429	54913	4019	20261	9740	25913	68178	90268	0	**323021**	226782	120353	3247	2737	0	**353119**	**30098**		
PV:																				
2%	$42,929	$13,181	$32,353	$2,339	$14,777	$6,917	$15,078	$39,671	$52,524	$0	**$219,770**	$131,959	$70,030	$1,889	$1,509	$0	**$205,388**	**($14,382)**		
4%	$47,092	$8,423	$20,752	$1,477	$11,406	$5,178	$9,519	$25,046	$33,160	$0	**$162,052**	$83,310	$44,212	$1,193	$907	$0	**$129,622**	**($32,430)**		
6%	$47,404	$5,777	$14,307	$999	$9,234	$4,075	$6,442	$16,948	$22,439	$0	**$127,626**	$56,375	$29,918	$807	$588	$0	**$87,687**	**($39,939)**		

Discount Rate	B/C Ratio	NPV	IRR
2%	0.93	($14,382)	
4%	0.80	($32,430)	1.14%
6%	0.69	($39,939)	
0%	1.09	$30,098	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	54600
Col.2	O&M/year ($,000) + $15/acre	251
Col.3	Diversion Pumping-Energy $,000/yr.	1111
Col. 4	Municipal Pumping-Energy $,000/yr.	83
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incr. Crop Revenue/acre	344.34
Col. 13	Annual Incr. Live.Revenue/acre	182.74
Col. 14	Stockwater/acre	4.93
Col. 15	Recreation/acre (+1.4%/yr.)	2.87
Col. 16	Other Incr. Benefits	0

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, February 2005

Table 3.11. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 2 (22,000 acres)

$ Thousands 2004-05

	INCREMENTAL COSTS											INCREMENTAL BENEFITS								
Project Year	Project Capital+Engineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCREMENTAL COSTS	Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreation	Other Incre. Benefits	TOTAL INCREMENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	1	2	3	4	5	6	7	8	9	10	**11**	12	13	14	15	16	**17**	**18**	19	20
1	26367	0	0	0	0	0	0	0	0	0	**26367**	0	0	0	0	0	**0**	**-26367**		
2	26367	0	0	0	0	0	0	0	0	0	**26367**	0	0	0	0	0	**0**	**-26367**		
3	26367	0	1705	0	0	0	0	0	0	0	**28072**	0	0	0	0	0	**0**	**-28072**		
4	0	361	255.8	12.5	2585.0	996.6	138.1	341.6	452.3	0	**5142**	1136.3	603.0	16.3	9.5	0	**1765**	**-3377**	3300	3300
5	0	410	511.5	24.9	2585.0	996.6	276.2	683.2	904.6	0	**6392**	2272.6	1206.1	32.5	19.2	0	**3530**	**-2862**	6600	3300
6	0	460	767.3	37.4	2585.0	996.6	414.3	1024.8	1356.9	0	**7642**	3409.0	1809.1	48.8	29.2	0	**5296**	**-2346**	9900	3300
7	0	509	1023.0	49.8	2585.0	996.6	552.4	1366.5	1809.2	0	**8892**	4545.3	2412.2	65.1	39.5	0	**7062**	**-1829**	13200	3300
8	0	559	1278.8	62.3	2585.0	996.6	690.6	1708.1	2261.5	0	**10141**	5681.6	3015.2	81.3	50.1	0	**8828**	**-1313**	16500	3300
9	0	608	1534.5	74.7	2585.0	996.6	828.7	2049.7	2713.8	0	**11391**	6817.9	3618.3	97.6	60.9	0	**10595**	**-796**	19800	3300
10	0	641	1705.0	83.0	1723.4	664.4	920.7	2277.4	3015.3	0	**11030**	7575.5	4020.3	108.5	68.6	0	**11773**	**743**	**22000**	2200
11	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	69.6	0	**11774**	**3131**	22000	
12	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	70.6	0	**11775**	**3132**	22000	
13	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	71.6	0	**11776**	**3133**	22000	
14	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	72.6	0	**11777**	**3134**	22000	
15	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	73.6	0	**11778**	**3135**	22000	
16	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	74.6	0	**11779**	**3136**	22000	
17	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	75.6	0	**11780**	**3137**	22000	
18	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	76.7	0	**11781**	**3138**	22000	
19	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	77.8	0	**11782**	**3139**	22000	
20	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	78.9	0	**11783**	**3141**	22000	
21	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	80.0	0	**11784**	**3142**	22000	
22	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	81.1	0	**11785**	**3143**	22000	
23	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	82.2	0	**11786**	**3144**	22000	
24	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	83.4	0	**11788**	**2148**	22000	
25	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	84.5	0	**11789**	**2150**	22000	
26	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	85.7	0	**11790**	**2151**	22000	
27	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	86.9	0	**11791**	**2152**	22000	
28	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	88.1	0	**11792**	**2153**	22000	
29	0	641	1705.0	83.0	2585.0	996.6	920.7	2277.4	3015.3	0	**12224**	7575.5	4020.3	108.5	89.4	0	**11794**	**-431**	22000	
30	0	641	1705.0	83.0	2585.0	664.4	920.7	2277.4	3015.3	0	**11892**	7575.5	4020.3	108.5	90.6	0	**11795**	**-97**	22000	
31	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**	7575.5	4020.3	108.5	91.9	0	**11796**	**569**	22000	
32	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**	7575.5	4020.3	108.5	93.2	0	**11797**	**570**	22000	
33	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**	7575.5	4020.3	108.5	94.5	0	**11799**	**571**	22000	
34	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**	7575.5	4020.3	108.5	95.8	0	**11800**	**573**	22000	
35	0	641	1705.0	83.0	1723.4	0	920.7	2277.4	3015.3	0	**10366**	7575.5	4020.3	108.5	97.2	0	**11801**	**1436**	22000	
36	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	98.5	0	**11803**	**3160**	22000	
37	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	99.9	0	**11804**	**3162**	22000	
38	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	101.3	0	**11806**	**3163**	22000	
39	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	102.7	0	**11807**	**3164**	22000	
40	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	104.2	0	**11808**	**3166**	22000	
41	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	105.6	0	**11810**	**3167**	22000	
42	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	107.1	0	**11811**	**3169**	22000	
43	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	108.6	0	**11813**	**3170**	22000	
44	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	110.1	0	**11814**	**2175**	22000	
45	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	111.7	0	**11816**	**2177**	22000	
46	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	113.2	0	**11817**	**2178**	22000	
47	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	114.8	0	**11819**	**2180**	22000	
48	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	116.4	0	**11821**	**2182**	22000	
49	0	641	1705.0	83.0	0	996.6	920.7	2277.4	3015.3	0	**9639**	7575.5	4020.3	108.5	118.0	0	**11822**	**2183**	22000	
50	0	641	1705.0	83.0	0	664	920.7	2277.4	3015.3	0	**9307**	7575.5	4020.3	108.5	119.7	0	**11824**	**2517**	22000	
51	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	121.4	0	**11826**	**3183**	22000	
52	0	641	1705.0	83.0	0	0	920.7	2277.4	3015.3	0	**8643**	7575.5	4020.3	108.5	123.1	0	**11827**	**3185**	22000	
53	-39550.01	641	1705.0	83.0	-2033.55	-4600.97	920.7	2277.4	3015.3	0	**-37542**	7575.5	4020.3	108.5	124.8	0	**11829**	**49371**	22000	
																			22000	
PV 0%	39550	31110	82096	3913	32433	15331	43413	107381	142172	0	**497400**	357184	189556	5114	4344	0	**556198**	**58798**		
PV:																				
2%	$62,192	$18,138	$47,741	$2,246	$23,525	$10,731	$24,914	$61,623	$81,589	$0	**$332,699**	$204,979	$108,782	$2,935	$2,369	$0	**$319,064**	**($13,635)**		
4%	$68,222	$11,485	$30,167	$1,395	$17,912	$7,903	$15,472	$38,270	$50,670	$0	**$241,496**	$127,299	$67,557	$1,823	$1,402	$0	**$198,081**	**($43,415)**		
6%	$68,676	$7,801	$20,473	$927	$14,253	$6,111	$10,283	$25,434	$33,675	$0	**$187,632**	$84,602	$44,898	$1,211	$894	$0	**$131,604**	**($56,027)**		

Discount Rate	B/C Ratio	NPV	IRR
2%	0.96	($13,635)	
4%	0.82	($43,415)	1.46%
6%	0.70	($56,027)	
0%	1.12	$58,798	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	79100
Col.2	O&M/year ($,000) + $15/acre	311
Col.3	Diversion Pumping-Energy $,000/yr.	1705
Col. 4	Municipal Pumping-Energy $,000/yr.	83
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	344.34
Col. 13	Annual Incre. Live.Revenue/acre	182.74
Col. 14	Stockwater/acre	4.93
Col. 15	Recreation/acre (+1.4%/yr.)	2.87
Col. 16	Other Incre. Benefits	0

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Table 3.12. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 3 (27,000 acres) $ Thousands 2004-05

	INCREMENTAL COSTS											INCREMENTAL BENEFITS							
Project Year	Project Capital+Eng-ineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+ O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreat-ion	Other Incre. Benefits	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	32033	0	0	0	0	0	0	0	0	0	32033	0	0	0	0	0	0	-32033	
2	32033	0	0	0	0	0	0	0	0	0	32033	0	0	0	0	0	0	-32033	
3	32033	0	1934	0	0	0	0	0	0	0	33967	0	0	0	0	0	0	-33967	
4	0	381	236.4	22.7	2419.8	996.6	140.6	341.6	452.3	0	4991	1136.3	603.0	16.3	9.5	0	1765	-3225	3300
5	0	430	472.8	45.5	2419.8	996.6	281.2	683.2	904.6	0	6234	2272.6	1206.1	32.5	19.2	0	3530	-2703	6600
6	0	480	709.1	68.2	2419.8	996.6	421.8	1024.8	1356.9	0	7477	3409.0	1809.1	48.8	29.2	0	5296	-2181	9900
7	0	529	945.5	90.9	2419.8	996.6	562.4	1366.5	1809.2	0	8720	4545.3	2412.2	65.1	39.5	0	7062	-1658	13200
8	0	579	1181.9	113.7	2419.8	996.6	703.0	1708.1	2261.5	0	9963	5681.6	3015.2	81.3	50.1	0	8828	-1135	16500
9	0	628	1418.3	136.4	2419.8	996.6	843.5	2049.7	2713.8	0	11206	6817.9	3618.3	97.6	60.9	0	10595	-611	19800
10	0	678	1654.6	159.1	2419.8	996.6	984.1	2391.3	3166.1	0	12449	7954.3	4221.3	113.9	72.1	0	12361	-88	23100
11	0	727	1891.0	181.9	2419.8	996.6	1124.7	2732.9	3618.4	0	13692	9090.6	4824.3	130.2	83.5	0	14129	436	26400
12	0	736	1934.0	186.0	440.0	181.2	1150.3	2795.0	3700.6	0	11123	9297.2	4934.0	133.1	86.6	0	14451	3328	27000
13	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	87.8	0	14452	3950	27000
14	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	89.0	0	14453	3951	27000
15	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	90.3	0	14455	3953	27000
16	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	91.6	0	14456	3954	27000
17	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	92.8	0	14457	3955	27000
18	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	94.1	0	14458	3956	27000
19	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	95.5	0	14460	3958	27000
20	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	96.8	0	14461	3959	27000
21	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	98.2	0	14462	3960	27000
22	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	99.5	0	14464	3962	27000
23	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	100.9	0	14465	3963	27000
24	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	102.3	0	14467	2968	27000
25	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	103.8	0	14468	2969	27000
26	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	105.2	0	14469	2971	27000
27	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	106.7	0	14471	2972	27000
28	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	108.2	0	14472	2974	27000
29	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	13918	9297.2	4934.0	133.1	109.7	0	14474	556	27000
30	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	13918	9297.2	4934.0	133.1	111.2	0	14476	557	27000
31	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	13918	9297.2	4934.0	133.1	112.8	0	14477	559	27000
32	0	736	1934.0	186.0	2419.8	181.2	1150.3	2795.0	3700.6	0	13103	9297.2	4934.0	133.1	114.4	0	14479	1376	27000
33	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	12922	9297.2	4934.0	133.1	116.0	0	14480	1558	27000
34	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	12922	9297.2	4934.0	133.1	117.6	0	14482	1560	27000
35	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	12922	9297.2	4934.0	133.1	119.2	0	14484	1562	27000
36	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	12922	9297.2	4934.0	133.1	120.9	0	14485	1563	27000
37	0	736	1934.0	186.0	440.0	0	1150.3	2795.0	3700.6	0	10942	9297.2	4934.0	133.1	122.6	0	14487	3545	27000
38	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	124.3	0	14489	3987	27000
39	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	126.1	0	14490	3988	27000
40	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	127.8	0	14492	3990	27000
41	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	129.6	0	14494	3992	27000
42	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	131.4	0	14496	3994	27000
43	0	736	1934.0	186.0	0	0	1150.3	2795.0	3700.6	0	10502	9297.2	4934.0	133.1	133.3	0	14498	3996	27000
44	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	135.1	0	14499	3001	27000
45	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	137.0	0	14501	3003	27000
46	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	138.9	0	14503	3005	27000
47	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	140.9	0	14505	3007	27000
48	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	142.9	0	14507	3009	27000
49	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	144.9	0	14509	3011	27000
50	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	146.9	0	14511	3013	27000
51	0	736	1934.0	186.0	0	996.6	1150.3	2795.0	3700.6	0	11499	9297.2	4934.0	133.1	148.9	0	14513	3015	27000
52	0	736	1934.0	186.0	0	181.2	1150.3	2795.0	3700.6	0	10683	9297.2	4934.0	133.1	151.0	0	14515	3832	27000
53	-48050.00961	736	1934.0	186.0	-3062.17	-5952.42	1150.3	2795.0	3700.6	0	-46563	9297.2	4934.0	133.1	153.1	0	14517	61080	27000
																			27000
PV 0%	48050	35342	91672	8630	36535	18510	53374	129690	171709	0	593511	431389	228937	6176	5270	0	671772	78261	
PV:																			
2%	$75,558	$20,500	$52,913	$4,914	$26,372	$12,845	$30,388	$73,837	$97,760	$0	$395,086	$245,605	$130,342	$3,516	$2,854	$0	$382,317	($12,769)	
4%	$82,885	$12,904	$33,154	$3,023	$19,911	$9,374	$18,697	$45,430	$60,149	$0	$285,527	$151,114	$80,196	$2,164	$1,676	$0	$235,150	($50,377)	
6%	$83,435	$8,711	$22,305	$1,989	$15,686	$7,177	$12,301	$29,889	$39,573	$0	$221,066	$99,419	$52,761	$1,423	$1,058	$0	$154,663	($66,403)	

Discount Rate	B/C Ratio	NPV	IRR
2%	0.97	($12,769)	
4%	0.82	($50,377)	1.59%
6%	0.70	($66,403)	
0%	1.13	$78,261	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	96100
Col.2	O&M/year ($,000) + $15/acre	331
Col.3	Diversion Pumping-Energy $,000/yr.	1934
Col. 4	Municipal Pumping-Energy $,000/yr.	186
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	344.34
Col. 13	Annual Incre. Live.Revenue/acre	182.74
Col. 14	Stockwater/acre	4.93
Col. 15	Recreation/acre (+1.4%/yr.)	2.87
Col. 16	Other Incre. Benefits	0

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The empirical results of Tables 3.10, 3.11, and 3.12 are summarized in Table 3.13 following.

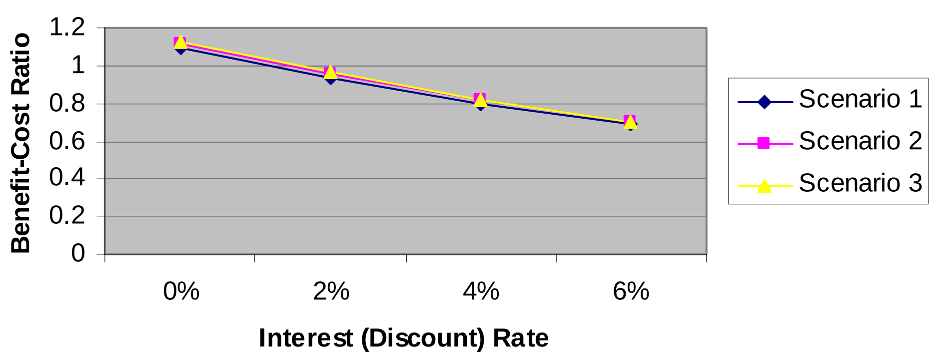
Table 3.13. Summary of Provincial Cash Flow Analysis

Criteria	Scenario 1 (Table 3.9)	Scenario 2 (Table 3.10)	Scenario 3 (Table 3.11)
IRR	**1.14%**	**1.46%**	**1.59%**
B/C Ratio:			
0%	1.09	1.12	1.13
2%	0.93	0.96	0.97
4%	0.80	0.82	0.82
6%	0.69	0.70	0.70
NPV: ($M)			
0%	30.1	58.8	78.3
2%	-14.4	-13.6	-12.8
4%	-32.4	-43.4	-50.4
6%	-39.9	-56.0	-66.4

The Internal Rate of Return (IRR) is estimated to range from 1.14%/year to 1.59%/year for Scenarios 1, 2, and 3, respectively. The rates-of-return for Scenarios 2 and 3 are fairly similar, although Scenario 3 does look slightly better. In todays' financial markets, the GOA might also consider the projected real rates-of-return (net of inflation) for Scenarios 2 and 3 "acceptable".

Estimated Benefit-Cost ratios are consistent with the corresponding IRR's. For Scenarios 2 and 3, the B/C ratio will exceed unity for any discount rate less than about 1.5% per annum while it will be less than unity for any discount rate in excess of about 1.5% per annum. (Figure 3.3).

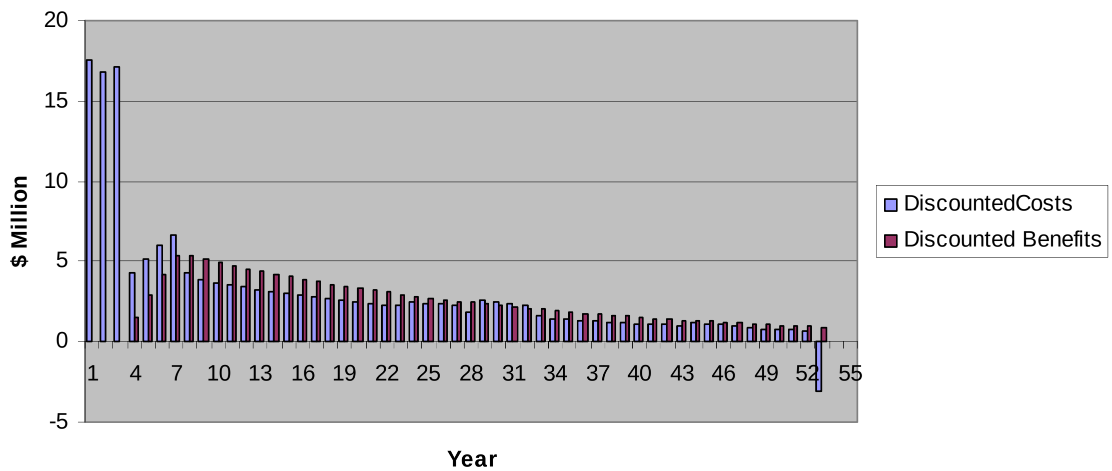
Figure 3.3. BENEFIT-COST RATIO AT VARIOUS INTEREST RATES



Similarly, for Scenarios 2 and 3 we would expect a negative NPV if the discount rate was more than about 1.5% per annum; a positive NPV if the discount rate was less than about 1.5% per annum.

Note, as well, that discounting future costs and benefits at various rates effectively gives more emphasis to costs and benefits which arise early in the project cycle; less to costs and benefits which arise late in the project cycle. For most "irrigation" projects, costs tend to be concentrated in the near-term; benefits in the longer-term. (Figure 3.4)

Figure 3.4. SCENARIO 3 -DISCOUNTED CASH FLOWS @ 4% DISCOUNT RATE



3.5 Sensitivity Tests

An accompanying sensitivity analysis is invaluable for at least three reasons:

1. There is risk and uncertainty. No one knows exactly how the future will unfold.
2. Errors and omissions. Sometimes accurately expressing everything in dollars may be difficult.
3. To facilitate optimum project design.

The focus here is on six variables which are often the most important, problematic, or uncertain.

3.5.1 Adjustment for Regional Income Disparities

As profiled in Section 4.1.3 the average annual earnings) for all persons with earning in Acadia Valley MD #34 in 2001 was $26,158, about 80% of the Alberta average. Worse, average earnings for full time workers of $28,472/year only represented about 65% of the Alberta average.

The underlying rationale for adjusting the provincial socio-economic benefit-cost analysis to account for this prevailing income disparity is that the marginal value of a dollar to a relative poor person is greater than it is to a relatively rich person.[34] International socio-economic feasibility studies employ numerous methodologies to take this into account.[35] For the purposes of this study, Sensitivity Test #1 inflates the value of the projected net benefits to Acadia by 25 percent. For Scenario 3, this increases the IRR from 1.59% (Base Case) to about 2.98 percent. Employing a 4% discount rate, the B/C ratio similarly climbs from 0.82 to 0.92.

3.5.2 Real Agricultural Product Price (Yield or Cropping Intensity) Changes

The Base Case analysis also assumes that real agricultural product prices (based on realized market prices during the past decade), yields, and cropping patterns will be such that the real gross margin remains the same over a 50 year period.. Yet realized market prices already reflect international price distortions (estimated by some to be about minus 50 cents per bushel) and it is almost inevitable that average yields will gradually increase and that cropping patterns will also gradually shift to an increasingly profitable crop mix over time. Sensitivity #2 asks how a 20% increase in real product prices (yields, or cropping intensities) would impact on the Base Case analysis. For Scenario 3, this increases the IRR from 1.59% (Base Case) to about 3.82 percent/year. Employing a 4% discount rate, the B/C ratio climbs from 0.82 to 0.99. This underlines, in short, how sensitive the Base Case analysis is to assumed agricultural product prices, yields, and cropping patterns.

3.5.3 Real Agricultural Cost-of-Production Changes

Potentially offsetting real agricultural cost-of-production (COP) increases are equally worrisome. Historically, real input (incl. energy) price increases have continued to squeeze farm margins. Sensitivity #3 asks what happens if these real costs eventually increase, say, 20 percent? For Scenario 3, the expected IRR would drop from 1.59% to a miniscule 0.12%/annum while the B/C ratio (at i=4%) would probably drop from 0.82 to 0.76. This negative impact would be almost as devastating as upward price/yield/crop mix adjustments would be beneficial. This is the dynamic of the infamous “cost-price squeeze” in primary agriculture.

3.5.4 Real Project Capital Cost Changes

Existing capital cost estimates all include a 25 percent contingency. But subsequent cost overruns are still possible.[36] Sensitivity #4 asks what impact a 20% increase in capital costs would have on project feasibility. This simulation, for Scenario 3, indicates that the IRR would probably drop from 1.59% to about 1.21% while the B/C ratio would likely drop from 0.82 to 0.78. The Base Case is somewhat less sensitive to capital cost changes than one might expect.

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[34] All so-called progressive taxes (e.g. income tax) are based on this logic.

[35] See, for example: 1) UNIDO, **Guide to Practical Project Appraisal: Social Benefit-Cost Analysis in Developing Countries,** New York, 1978; 2) Asian Development Bank, **Guidelines for the Economic Analysis of Projects,** Manila, 1997; and 3) Ministry of Public Works, **Economic and Financial Appraisal of Water Resources Development Projects**, Jakarta, 1974.

[36] Internationally, **ex post** studies by the World Bank indicate that cost overruns and project delays have been the two most important reasons why **ex ante** feasibility studies over-estimated realized project performance.

3.5.5 Real Project Operating Cost Changes

Operating costs are also a particular concern, particularly with regard to energy costs. For example, does a $2005 cost estimate of $.075/kWh plus surcharges accurately reflect the future. Is the current energy "bubble" only temporary or will real energy prices actually increase over time?[37] Or, conversely, should the analysis be conducted utilizing a lessor socially-determined price for "green power"?[38] Sensitivity #5 asks what happens if projected real off-farm O&M costs for the project ultimately increase 20 percent? For Scenario 3, the resulting simulation indicates that the IRR would probably drop from 1.59% (Base Case) to about 1.17% while the B/C ratio (I = 4%) would probably drop from 0.82 to 0.80. This is quite similar to the expected impact if project capital costs increased by 20 percent. (Section 3.5.4 above.)

3.5.6 Impact of Water Deficiencies

Yield projections utilized in the Base Case already reflect periodic water deficits consistent with historic GOA irrigation design criteria elsewhere in the province. Nevertheless, it is useful to see how sensitive the economic analysis is to an additional 1 in 10 year deficit of, say, 100 mm (about 4"). This is approximately 25% of average application rates.

This simulation (Sensitivity #6) requires translating a water deficit into a revenue loss, as reflected in Figure 2.2, Sub-Section 2. Thus, based on prior studies[39], a 25% water loss is here expected to result in an estimated revenue loss of approximately 15 percent. This is assumed to arise once every 10 years.

The resulting revisions suggest that for Scenario 3 the IRR would drop from 1.59 to 1.48 while the B/C ratio would drop only fractionally. Although this would obviously have a very negative short-term on-farm impact, overall project profitability would not be greatly affected.

3.5.7 Summary of Sensitivities

A summary of the sensitivity tests conducted, as described above, is provided in Table 3.14.

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[37] As of this writing, oil prices exceed US$50 per barrel and natural gas prices (which Alberta energy increasingly depends upon) are also relatively high.

[38] The recent **Meridian Dam** study (Golder, 2002) assumed the cost of "green" hydro-power was only $0.050/kWh (or $50/MWh).

[39] MAA, **Profile of Irrigation in the Highwood-Little Bow** (draft), AE/PAC, Calgary, 2003.

Table 3.14. Provincial Sensitivity Analysis, Water Development Scenario #3

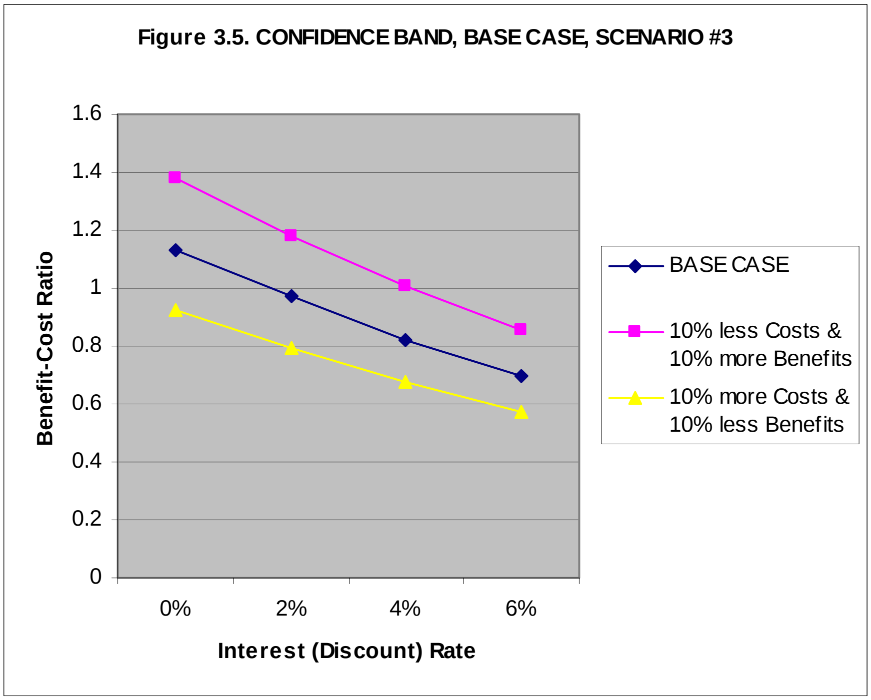
Criteria	**BASE CASE**	#1 Adjustment for Regional Income Disparity: Net Benefits +25%	#2 Real Ag. Product Prices or Cropping Intensities Increase +20%	#3 Real Ag. Costs-of-Production Increase +20%	#4 Real Project Capital Costs Increase +20%	#5 Real Project Operating Costs Increase +20%	#6 Water Deficiencies of 20% (100mm) arise every 10th year
IRR	**1.59%**	**2.98%**	**3.82%**	**0.12%**	**1.21%**	**1.17%**	**1.48%**
B/C Ratio:							
0%	1.13	1.27	1.35	1.01	1.11	1.09	1.12
2%	0.97	1.08	1.16	0.88	0.93	0.94	0.96
4%	0.82	0.92	0.99	0.76	0.78	0.80	0.82
6%	0.70	0.78	0.84	0.65	0.65	0.68	0.69
NPV ($M):							
0%	78.3	157.5	210.3	5.6	68.7	56.6	72.7
2%	-12.8	32.3	62.4	-54.1	-27.9	-25.3	-16.0
4%	-50.4	-22.7	-4.1	-75.8	-67.0	-58.3	-52.4
6%	-66.4	-48.2	-36.0	-83.2	-83.1	-71.7	-67.7

These particular sensitivity tests (above) are all conducted holding every other variable constant (the so-called **ceterus paribus** condition).

To simultaneously consider changes to all of the variables quantified in the Base Case (Section 3.4), a general confidence band can be established which should bracket the realized IRR's, B/C ratios, and NPV's. This we define as:

LOW: All Costs + 10% and All Benefits – 10%
HIGH: All Costs – 10% and All Benefits + 10%

For Scenario 3, this confidence band is illustrated in Figure 3.5. At a 4% discount rate, although the Base Case indicates that the B/C ratio will likely be about 0.82, it could be as low as 0.67 or as high as 1.01. **The corresponding confidence band for the estimated annual internal rate of return (IRR) is 1.0% and 4.08 percent.**



Given the present proposals and the existing cost and price structure, we are very confident that the "real" B/C ratio and the "real" IRR should lie somewhere within these confidence bands.

3.5.8 Summary

- The provincial socio-economic cash flow analysis (often referred to as a "benefit-cost" analysis) indicates that the IRR for Scenarios 1, 2, and 3 are 1.14%, 1.44%, and 1.59%, respectively. With a 4% discount rate, the corresponding benefit-cost ratios are 0.80, 0.82, and 0.82. This suggests, firstly, that none of these proposed projects are economically feasible if a real internal rate of return (IRR) of greater than, say, 1.6% is required by investors. At the same time, from a purely economic perspective, Scenarios 3 appears to be marginally better than Scenario 2 while both Scenarios 2 and 3 appear preferable to Scenario 1.

- There is considerable uncertainty and professional judgment embodied in all benefit-cost analyses and, as such, the confidence band for point estimates of the IRR, B/C ratio, and NPV is relatively wide. Compared to a Scenario 3 Base Case IRR of 1.59%, the confidence band for the annual internal rate of return (IRR) is a low of 1.0% and a high of 4.08 percent. Similarly, although the Scenario 3 Base Case indicates that the B/C ratio (where i=4%) will likely be about 0.82, it could be as low as 0.67

or as high as 1.01. This level of accuracy is very consistent with what other analysts expect.[40]

- In the final analysis, a provincial benefit-cost analysis is particularly important only as a systematic and comprehensive way to simultaneously look at all the socio-economic variables on one canvass. The numbers themselves are particularly important as a means of addressing all of the relevant factors simultaneously, as well as helping to communicate these findings to others.

- Ultimately, a provincial benefit-cost analysis is only one of many inputs required in the decision-making process. From an economic perspective, the findings of a complimentary farm financial analysis (Sub-Section 2) and a regional impact analysis (Sub-Section 4) are equally important. Numerous other non-economic considerations must also be factored into the decision-making matrix.

[40] One source notes: "The range of uncertainty about all variables is usually such that a difference of at least 2% in the internal rate of return (IRR) is required to be significant and even this may not be conclusive". See: UN, **Guide to Practical Project Appraisal,** N.Y., 1978, p. 15.

4. REGIONAL IMPACT ANALYSIS

4.1 Existing Socio-Economic Conditions[41]

4.1.1 Physical Characteristics

Acadia Municipal District #34 consists of about 288,000 acres (or 117,000 ha.) of relatively flat, semi-arid short-grass prairie (brown soil) bordered on the south by the Red Deer River (for about 30 miles/50 km.), the north and west by Special Area #3, and the east by the Saskatchewan border.

The area is one of the warmest and driest in the province. Precipitation is only about 325 mm (12.7") per annum, the average July temperature is about 18.2 ^{o}C, the degree days > 5 ^{o}C is about 1590, and the growing season is about 190 days. [42] This is less precipitation than in most Irrigation Districts in southern Alberta. The strong winds and high summer temperatures also contribute to the mean moisture deficit and this is further exacerbated by the shallow snow depth and relatively few days of continuous snow cover.

Primary Highway #41 (Buffalo Trail) bisects the District from north to south (30 miles/50 km.); Secondary Highway #565 bisects the District from west to east (30 miles/50 km.). There are an additional 36 miles (58 km.) of municipal highways, 380 miles (600 km.) of improved municipal roads and 180 miles (290 km.) of bladed trails within the District.

Oyen (pop. 1,074, immediately north), Empress (pop.186, immediately south), and the centrally-located hamlet of Acadia Valley (pop.120) are the three closest service centres. The principal trading centres for larger purchases are Oyen, Medicine Hat (125 km. south), and Hanna (150 km. NW). Drumheller, Brooks and Calgary are also fairly frequent destinations.

4.1.2 Population Characteristics

The population of the District has remained relatively static during the past decade:

1991	522
1996	533
2001	512

Of the 512 people now living in the District, about 120 live in the hamlet of Acadia Valley and about 50 are members of the Acadia Hutterian Brethern Colony.

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[41] Unless otherwise noted, most data are taken directly from: Statistics Canada, **Community Profiles**, various years. See http://www.statcan.ca.

[42] Data for Oyen extracted from: Heywood, R. T., **et. al., Agroclimatic Atlas of Alberta**, AAFRD, Lethbridge, 1990.

Source: www.mdacadia.ab.ca

The median age of the population is 35.5 (very similar to the Alberta average) and English was the first learned and still understood language of 76% of all residents. French is not spoken by anyone. There are 184 private dwellings (households) in the region (with about 40-50 in the hamlet of Acadia Valley itself) with a population density of about 0.5 persons per square kilometer.

4.1.3 Employment & Income Characteristics

Employment in the region is highly-dependent upon agriculture and other resource-based activities, primarily oil and gas. Most other people are involved in some type of service industry and almost no one is engaged in manufacturing or construction.

Average annual earnings (2001) for all persons with earnings in Acadia MD #34 was $26,158, about 80% of the Alberta average. Average earnings for full-time workers of $28,472/year, however, only represented about 65% of the Alberta average.

On the other hand, medium household income in the region in 2001 was $51,677, about 98% of the Alberta-wide average. In essence, people work harder in the region to compensate for below-average earnings. Labour participation rates are relatively high (91% versus 72% for all-Alberta) and unemployment in the region is negligible. (Table 4.1)

Table 4.1. Employment & Incomes, M.D. of Acadia

Sector	Number (%)
Agriculture/Resource-Based*	235 (65%)
Manufacturing/Construction*	10 (3%)
Service Industries*	115 (32%)
TOTAL*	360 (100%)
Average Earnings, All Persons with Earnings	$26,158
Average Earnings, Full Time/Full Year Workers	$28,472
Medium Household Income-All Households**	$51,677
Unemployment Rate (1996)**	0.0%
Participation Rate (1996)**	91.1%

* Data for 1995. ** Data for 2001. All Alberta estimate = $52,524.
***Comparable all-Alberta rates are about 5% and 72% respectively.

Multiplying average earnings (all persons) by total employment suggests a total income for the region of about $9.4 M. per annum. And this, in turn, implies a Gross Domestic Product (GDP) of perhaps $16.5 M per annum with sales of maybe $ 37 M per annum.[43] These are just order-of-magnitude estimates, important only as baseline data for the impact analysis which follows.

4.1.4 Agricultural Profile

The existing land base is approximately as follows:

Dryland Cultivation	177,000 acres
Native Grasslands	93,000
Improved pasture/hay	4,800
Irrigation	1,200
Total	276,000 acres

Thus, with about 105 dryland farmers[44] in MD Acadia #34, average (non-Hutterite) farm size is approximately 2500 acres.

4.2 Regional Impact of Development Alternatives

4.2.1 Analytical Framework

The regional impact of project implementation on four economic variables is particularly important: 1) sales and direct expenditures; 2) gross domestic product (GDP or value-added); 3) employment; and 4) income.

To approximate regional impacts, the methodology employed utilizes four data sets:

- Estimated incremental expenditures.
- Estimated expenditure patterns.

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[43] Very approximate. Estimated by employing a GDP/income ratio of 1.75 and a sales/GDP ratio of 2.25. Estimates for specific sectors can be derived from the Provincial Accounts.
[44] Approximate. Information from Gary Peers, MD Acadia #34, January 2005.

- Provincial expenditure "multipliers".
- Employment characteristics

This is a very approximate procedure which is utilized solely to generate **comparative order-of-magnitude estimates.** In a relative sense, how important would one of these developments be to Acadia MD #34?

Estimated **incremental expenditures** are drawn directly from the preceding provincial benefit-cost analysis, Tables 3.10, 3.11, and 3.12: Initial capital investment from the summation of Col. (1); system operating costs from the summation of Cols. (2), (3), and (4); on-farm capital requirements from Cols. (5) and (6); and on-farm operating costs from Cols. (7), (8), and (9). These are summarized following: ($M)

Table 4.2 Incremental Expenditure Levels, Years 1-53 $2005 million

Expenditure	Scenario 1	Scenario 2	Scenario 3
System Capital	54.6	79.1	96.1
System O&M	81.4	117.8	135.6
Farm Capital	30.0	47.8	55.0
Farm Operating	184.4	293.0	354.8

Secondly, **expenditure patterns** are approximated for Acadia MD #34, Other Alberta, and Non-Alberta, respectively, depending upon the type of expenditure anticipated.

Table 4.3 Projected Expenditure Patterns (%)

Item		**M.D. of Acadia**	**Other Alberta**	**Non-Alberta**	**TOTAL**
Infrastructure	Investment	10	85	5	100
	Operating/Yr.	20	75	5	100
Agriculture	Investment	10	70	20	100
	Operating/Yr.	20	70	10	100

Source: Percentages approximated from AE/PWSS **Little Bow Studies, Appendix P**, 1995.

The total impact on GDP, employment, and income is estimated by adding up three direct and indirect impacts: 1) initial direct impact; 2) indirect ripple effects (sometimes called "spin-offs"); and 3) an induced income effect as incomes are impacted and this, in turn, affects consumption levels. The relative strength of these respective inter-sectoral linkages is determined by adding up the cumulative ripple and induced income effects, as reflected in what are commonly termed **"multipliers".** For the province and for the sectors of particular interest, these are approximately as follows:

Table 4.4 Provincial Expenditure Multipliers for GDP, Income, and Employment

Item		GDP	Household Income	Employ-ment
Infrastructure	Investment	0.821	0.597	0.134
	Operating/Yr.	0.879	0.258	0.058
Agriculture	Investment	0.765	0.359	0.209
	Operating/Yr.	0.765	0.359	0.209

Source: Taken directly from Alberta Treasury, **Alberta Economic Multipliers,** 1997, 2001, Table 5, Industries 30, 35, and 01, respectively. Applied to expenditure levels.

.Employment multipliers are per $10,000 of expenditures.

Finally, it is also necessary to correctly anticipate labour characteristics, particularly capital-labour ratios. With respect to initial capital expenditures, it is expected that approximately 1/3 of the total cost will consist of wages and salaries and that the average wage/salary (incl. overheads) will be approximately $100,000/person per year.[45] For system O&M, it is expected that 4 person years of employment/year will be required. Employment projections for agriculture were derived using employment/GDP ratios.

4.2.2 Empirical Results

A summary of the estimated average annual regional impacts for Scenarios 1-3 is provided in Table 4.5 following.

[45] Approximate capital-labour percentage based on AE/PWSS, **Little Bow Studies**, 1995. Labour costs for construction are based on a 2003 estimate of $93,000/labourer/year.

Table 4.5. Summary of Average Annual Regional Impacts

Variable	SCENARIOS 1	2	3
Av. Annual Sales, Agriculture, Project Maturity			
$ Million	7.2	11.6	14.2
Percent of Region	19%	31%	38%
Av. Annual Direct Expenditure, Years 1-3:			
$ Million	1.8	2.6	3.2
Av. Annual Direct Expenditure, Years 4-53:			
$ Million	1.1	1.7	2.1
Av. Annual GDP Stimulus, Years 1-3:			
$ Million	1.5	2.2	2.6
Percent of Region	9%	13%	16%
Av. Annual GDP Stimulus, Years 4-53:			
$ Million	0.9	1.4	1.6
Percent of Region	5%	8%	10%
Av. Annual Employment Stimulus, Yrs. 1-3:			
Number	24	35	43
Percent of Region	7%	10%	12%
Av. Annual Employment Stimulus, Yrs. 4-53:			
Number	19	29	35
Percent of Region	5%	8%	10%
Av. Annual Income Stimulus, Years 1-3:			
$ Million	0.8	1.2	1.4
Percent of Region	9%	13%	15%
Av. Annual Income Stimulus, Years 4-53:			
$ Million	0.4	0.6	0.7
Percent of Region	4%	6%	7%

Regional Baseline:

Sales, total $M	37
GDP $M	16.5
Employment	360
Income $M	9.4

Source: For baseline data, see preceding text.

In terms of regional GDP, the annual stimulus during construction Years 1-3 would range from $1.5M to $2.6M per annum; 9-16 % of current GDP levels in the region. Thereafter, during Years 4-53, this would probably drop to between $0.9M and $1.6M per annum; 5-10 percent of current regional GDP.

At the same time, local employment would be expected to climb 7-12% during Years 1-3; 5-10% thereafter. This largely reflects construction employment by local personnel in Years 1-3; additional local employment in agriculture during Years 4-53.

Regional income, in turn, would be impacted in at least four different ways: 1) average income levels; 2) income stability; 3) income equity; and 4) savings and growth.

1. Average Income Levels

During the construction period, regional incomes are expected to increase an average of between $0.8M and $1.4M per year; a short-term stimulus of between 9% (Scenario 1) and 15% (Scenario 3) over current income levels in the region. (Table 4.5) This is a relatively large temporary impact. In the longer term, the additional irrigation development would likely add between $0.4M and $0.7M per year to local incomes. Increasing local incomes 4 to 7 percent in each of Years 4-53 is particularly important because it represents a self-sustainable long-term improvement in regional income levels.

2. Income Stability

The M.D. of Acadia economy is still highly dependent upon dryland agriculture and in this semi-arid environment, agricultural incomes fluctuate very considerably. (Sub-Section 1)
Additional irrigation development in the region would directly stabilize incomes for, say, 20 farmers; about 20% of all farmers in the region. This would reduce periodic cost-of-production losses, reduce the need for federal/provincial drought assistance, and reduce federal/provincial crop insurance costs. And reducing these losses, in turn, would reduce the number of farm failures and regional farm service closures.

3. Income Equity

Table 4.6 indicates that regional income levels in the basin in 2001 averaged – depending upon which criteria is utilized --between 65% and 80% of those elsewhere in the province.

Table 4.6 Summary of Relative Income, 2001

	Relative Income (income/person/year)		
	M.D. of Acadia	Province	% of Province
All Workers	$26,158	$32,603	80%
F.T. Workers	$28,472	$44,130	65%

Improved water management would enhance income levels between 9% and 15% percent in the first three years; between 4% and 7% per annum thereafter. Thus, this could seemingly narrow the existing regional income disparity by, say, 30 percent.

Although not included in the preceding provincial Benefit-Cost analysis (Sub-Section 3), this is also a potential socio-economic benefit to the region. The need for more geographically diversified economic growth in the province has been part of the rationale for previous water development projects elsewhere in the province. **(Little Bow Study, Appendix P**, p. 5-16)

4. Savings & Growth

Finally, an option value is the amount a person or community is willing to pay to preserve the option of being able to experience a particular amenity in the future. There is a social value assigned to some amenities simply because they exist and because they can be bequeathed to future generations.[46] An option/existence/bequest value should accurately reflect: 1) future growth opportunities; and 2) changing water demands by various users over time.

The most basic of all amenities is water and, thus, it is a prerequisite for further growth in the region. Irrespective of the location or legal/institutional framework, moreover, changing water demands by various users over time will virtually guarantee a long-term shift to increasingly high-valued water uses. This will gradually increase average real water values (and, thus, benefits) to the region and elsewhere[47]. As a consequence, although this “psychic income” is also not included in the preceding provincial Benefit-Cost analysis (Sub-Section 3), this is yet another very real long-term social benefit of enhanced water management in the M.D. of Acadia and elsewhere.

The detailed tabulations regarding regional GDP, employment and income impacts for Scenario 3 are provided in Attachments A-8 through A-12. Again, it should be stressed, however, that these are only useful as comparative order-of-magnitude estimates.

4.3 Regional Benefit-Cost Analysis

4.3.1 Background & Methodology

The provincial discounted cash flow analysis (Sub-Section 3 preceding) utilizes a provincial perspective to compare quantifiable projected benefits with quantifiable projected costs into the foreseeable future. This provincial “benefit-cost analysis” calculates the IRR, B/C ratio, NPV to determine if a proposed investment would or would not use Alberta resources efficiently.

These four efficiency criteria entirely ignore equity considerations since, it is argued, if the B/C ratio >1 for the province, then it should always be possible for those who gain from the implementation of a particular investment to compensate those who lose (if, indeed, there are losers) from project implementation. This calculus does not consider the possibility that a dollar directly or indirectly generated by a project may be worth more to a relatively poor community than to a relatively wealthy community.

From a regional perspective, however, this seems counter-intuitive. A regional perspective, it is argued, should also consider: 1) indirect impacts on the region; and 2) relative income disparities. Thus, to at least partially incorporate this into a regional benefit-cost framework, the following three-step procedure was utilized:

- In terms of changes to the regional Gross Domestic Product (i.e. value-added), calculate the **total** direct and indirect impact of project expenditures on the region over 53 years with respect to 1) initial capital expenditures; 2) system O&M; 3)

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[46] An **existence value** is a willingness to pay simply to help preserve the existence of a particular amenity. **Bequest** values are existence values which consider the anticipated value of an amenity to future generations.

[47] “Real” always means net of rates of inflation. That is, future increases in the nominal value of water will almost certainly increase faster than future rates of inflation.

on-farm capital expenditures; and 4) incremental on-farm costs-of-production (COP). From Section 4.2.2 preceding, these are: ($ 2005M)

Item	Scenario 1	Scenario 2	Scenario 3
System Capital	4	6	8
System O&M	14	21	24
On-Farm Capital	2	4	4
On-Farm COP	28	45	54

For average annual estimates, see Table 4.5. For additional details for Scenario 3, see Attachments A-8 through A-12.

- Revise the provincial-benefit-cost simulations to include these four regional impacts as benefits (i.e. additional value-added) which are actually captured by the region. Rather than using averages (as per Table 4.5), these total benefit calculations are also assumed to be exactly correlated to their corresponding cost over the 53 year period.
- Re-calculate the respective socio-economic efficiency criteria.

4.3.2 Regional Benefit-Cost Estimates

The provincial cash flow Tables 3.10, 3.11 and 3.12 were revised by incorporating four new regional benefits into the analysis:

- New Column (14): System construction, direct and indirect GDP captured by Acadia MD #34
- New Column (15): System O&M, direct and indirect GDP captured by Acadia MD #34
- New Column (16): Farm capital requirements, direct and indirect GDP captured by MD #34
- New Column (17): Annual on-farm costs-of-production, direct and indirect GDP captured by Acadia MD #34

No other changes were made. These simulated cash flows are attached, Attachments A-13, A-14, and A-15, and the results are summarized following:

Table 4.7. Summary of Regional Cash Flow Analysis

Criteria	**Scenario 1**	**Scenario 2**	**Scenario 3**
IRR	**2.94%**	**3.33%**	**3.39%**
B/C Ratio:			
0%	1.24	1.27	1.28
2%	1.07	1.10	1.11
4%	0.93	0.95	0.96
6%	0.81	0.83	0.83
NPV ($M):			
0%	78.1	134.8	168.3
2%	15.6	33.4	42.9
4%	-11.9	-11.4	-12.5
6%	-24.6	-32.5	-38.5

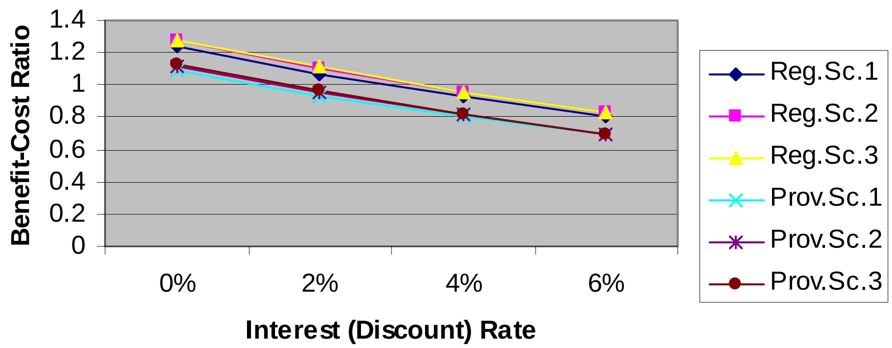
Source: Attachments A-13, A-14, and A-15.

From a regional perspective, the real economic internal rate of return (IRR, where B/C = 1 and NPV = 0) is equal to approximately 3% per annum, with Scenario 3 again most likely to slightly out-perform the other two development opportunities. This compares to a provincial IRR estimate of about 1.5% per annum.

From a regional perspective the B/C ratios and NPV estimates demonstrate a corresponding improvement, averaging about 0.95 if a 4 percent interest (discount) rate is employed. The comparable provincial B/C estimate is about 0.80. Thus, for Scenarios 2 and 3, at a 3 percent discount rate, the B/C should exceed unity and the Net Present Value (over 53 years) should be positive. This would suggest that from a regional socio-economic perspective, Scenarios 2 and 3 (with a slight preference to Scenario 3) could be a reasonably profitable investment opportunity.

Regional-provincial B/C estimates at different discount rates are compared in accompanying Figure 4.1. This graphic illustrates how the regional lines generally intersect the B/C = 1 point where the interest rate is approximately equal to 3%/annum whereas, from a provincial perspective, the corresponding intersection is approximately equal to 1.5% per annum. These are equivalent to the respective IRR values; the break-even interest rates; the respective real rates-of-return required before the proposed development alternatives would be considered feasible.

Figure 4.1. REGIONAL & PROVINCIAL BENEFIT-COST ESTIMATES



This regional assessment ascribes an incremental regional value to project “spinoffs” and it is determined that these “spinoffs” would likely inflate the respective B/C ratios by, say, 15 percent. At the same time, the corresponding IRR would approximately double. This is a very significant difference.

It is also important to note that this regional B/C procedure has, in this instance, generated benefit-cost estimates which are **almost identical to those calculated at a provincial level when existing regional income disparities (of, say, 25%) are incorporated into that analysis.** (Section 3.5, Sensitivity #1) In that framework, for Scenario 3 the IRR is equal to 2.98 and the B/C ratio with a 4% discount rate is 0.92. This further reinforces our professional judgement that if a real 3% per annum rate-of-return is considered adequate by the GOA, then this development option is probably a viable investment opportunity.

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Attachment A-1. Agricultural Product Prices, 1994-2003 and Related Estimates

PRODUCT	UNITS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	10-YEAR AVERAGE	Milk River Study,2004****	AAFRD 2004 COPS	CONCENSUS
All Wheat	bushel	4.69	5.70	4.13	3.90	3.75	3.31	3.50	3.96	4.62	3.86	**4.14**			
HRS													4.50	4.25	**4.25**
Durum													5.50	4.15	**4.50**
SWS													4.00	3.90	**4.00**
Winter														3.30	
Oats	bushel	1.36	2.61	1.56	1.89	1.81	1.57	1.55	2.44	2.87	2.49	**2.02**			
Barley	bushel	2.13	3.37	2.58	2.60	2.31	2.19	2.20	2.85	3.26	2.50	**2.60**	2.75	2.70	**2.60**
Flax	bushel	6.81	7.44	8.04	8.08	7.21	4.79	5.56	7.41	9.17	8.54	**7.31**			
Canola	bushel	7.94	8.44	9.07	8.57	7.85	5.75	5.44	6.49	7.98	7.54	**7.51**	7.00	7.50	**7.00**
All Rye	bushel	2.31	2.75	3.39	2.50	2.20	2.01	1.87	2.77	3.91	3.31	**2.70**			
Corn, Grain	bushel	3.54	3.53	4.07	4.33	4.23	3.59	3.47	3.82	n/a	n/a	**3.82**			
Dry Peas*	tonne	170	186	224	196	153	136	113	165	192.60	157.60	**169.32**	5.00	5.00	**4.61**
Dry Beans	cwt	25.78	26.82	30.97	29.15	27.38	25.97	23.59	26.81	28.21	21.58	**26.63**	25.00	25.00	
Lentils*****	tonne	325	419	409	286	325	402	371	311	379	457	**368.40**		0.16	
Chickpeas	lb.													0.20	**0.20**
Mustard**	tonne	264	320	398	366	368	321	285	479	685	542	**402.80**	0.18	0.18	**0.18**
Triticale	tonne	114	114	178.34	n/a	177.16	n/a	n/a	n/a	n/a	n/a	**145.88**			
Potatoes	cwt	7.81	8.72	8.13	7.43	8.71	8.63	8.27	7.71	8.81	9.12	**8.33**	130/tonne*	135/tonne***	
Sugar Beets	tonne													41.00	
Corn, Silage	n/a											**0.00**			
Canary Seed	lb.	n/a	0.21	0.19	0.14	0.12	0.11	0.11	0.16	0.32	0.20	**0.17**			
Sunflower	tonne	415	453	476	438	382	315	392	425	507	n/a	**422.56**			
Tame Hay	tonne	n/a	80.91	95.12	87.07	85.94	81.26	83.47	101.26	135.73	119.88	**96.74**			
Mixed Hay	tonne												80.00	75.00	**80.00**
Alfalfa	tonne												100.00		**90.00**
Export Timothy	tonne													126.00	
Timothy Seed	lb.												0.50		
Barley Silage	tonne												32.00	32.00	**32.00**
Corn Silage	tonne												32.00		
Slaughter Steers	cwt live	86.34	82.90	78.42	84	83.56	89.30	95.00	102.82	97.14	84.28	**88.38**			
Hogs, index =100	kg.	1.37	1.47	1.82	1.80	1.13	1.15	1.54	1.65	1.29	1.30	**1.45**			
Lamb (95-115 lbs.)	head	87.66	91.05	108.20	108.11	94.52	93.88	99.40	86.89	88.40	89.95	**94.81**			

*10 yr. average translates to $4.61/bushel. **10 yr. average translates to 0.18 per pound. *** Potatoes for processing.

**** Generally based on AAFRD long-term real price projections, exclusive of trends. *****10 year average translates to 0.17 per pound.

Source: Basic data series from AAFRD, **Agriculture Statistics Yearbook, 2003**, Edmonton, 2004.

Attachment A-2. Annual On-Farm O&M Irrigation Cost (2004-05$/acre and /hectare)

IRRIGATION SYSTEM MIX:

Irrigation Method	Equipment Type	Crop Area (%)***
Sprinkler	Hand-Move	5%
	Pivot-High Pressure	35%
	Pivot-Low Pressure	50%
	Wheel Move	10%
Flood-Gravity		0%
Total		100.0%

UNIT COSTS: (2004-05$)

Equipment Type	Labor $/mm/acre	R&M $/mm/acre	Energy $/mm/acre
Gravity	0.041	0.0026	0
Hd.Move/Wheel*	0.027	0.023	0.0788
Pivot-HP	0.0089	0.044	0.089
Pivot-LP	0.0089	0.045	0.065

WATER inches** 15.47

mm 393.0

TOTALS: (2004-05$)

Equipment Type	Labor	R&M	Energy	SUB-TOTAL Energy/R&M
Gravity	16.11	1.02	0.00	1.02
Hd.Move/Wheel	10.61	9.04	30.97	40.01
Pivot-HP	3.50	17.29	34.98	52.27
Pivot-LP	3.50	17.69	25.55	43.23
WT. AVERAGE/ACRE	**4.57**	**16.25**	**29.66**	**45.91**
Wt. Average/Ha.	11.28	40.16	73.30	113.46

* Also includes volume guns and travellers; about 1%.

** Estimate based on WRMM/IPM model. For details, see elsewhere.

Source: All basic cost data from AAFRD/Irrigation Branch, Lethbridge, 2003.

Attachment A-3. On-Farm Capital Costs of Irrigation Equipment (Electric) (2004-05$)

Type	**Item**	**HAND**	**WHEEL 2**	**WHEEL 4**	**Pivot HP**	**Pivot LP**
Percent**		**5.0%**	**5.0%**	**5.0%**	**35.0%**	**50.0%**
Pivot 1300'					58600	58600
Electric Engine	125 hp	9850	9850	9850	9850	9850
Switching Gear		6400	6400	6400	6400	6400
Vert.Turbine Pump	75-125 hp	7100	7100	7100	7100	7100
Pump House		5950	5950	5950	5950	5950
Suction Pipe	10"	1330	1330	1330	1330	1330
Low Pres. Package	1300'					4280
Wheel Roll	1/4 mile		12700	25400		
Hand Move - Pipe	1/4 mile	6000				
SUB-TOTAL		36630	43330	56030	89230	93510
3-Phase Electricity*		25000	25000	25000	25000	25000
TOTAL		61630	68330	81030	114230	118510
Area/Unit (Acres)		160	160	160	132	132
TOTAL/ACRE		$ 385	$ 427	$ 506	$ 865	$ 898
Total/Hectare		$ 952	$ 1,055	$ 1,251	$ 2,138	$ 2,218
WEIGHTED AV./ACRE						**$ 817.72**
Weighted Av./Ha.						$ 2,020.58
AV./ACRE w/o Electricity		127.38	169.25	248.63	552.88	585.30
					Weighted Av.	**513.42**

* Based on a cost estimate of $37,000/km. (or $50,000/mile) for two systems.

** See above, Irrigation System Mix.

Source: Cost data from AAFRD/Irrigation Branch, Lethbridge, 2003.

Appendix Table A-4. SOURCES & METHODOLOGICAL NOTES TO ACCOMPANY TABLE 2.3 AND TABLE 2.6

ITEM	Irrigation	Dryland
Crop Mix	Based on AAFRD estimates. Consistent with the water modelling. See Table 4.4 in main report.	Based on MPE estimates of cultivated, forage, and native grass in project area. Cultivated breakdown based on **2001 Census of Agriculture**, exclusive of summerfallow (since yields are based on stubble crops) and non-cultivated land.
Crop Sales	Yields X market price.	Yields X market price.
Crop Yields	Generally the same as AAFRD **2004 Production Costs (COP) and Returns, Irrigated Soils**.	Generally the same as AAFRD **2004 Production Costs and Returns, Brown Soils, Stubble Seeded Crops.**
Market Prices	An estimate of $2004 long-term prices. Generally based on 1994-2003 averages (Attachment A-1). Generally consistent with AAFRD non-trended long-term averages and AAFRD 2004 **COP** budgets. The same prices apply to both irrigated crops and dryland crops.	An estimate of $2004 long-term prices. Generally based on 1994-2003 averages (Attachment A-1). Generally consistent with AAFRD non-trended long-term averages and AAFRD 2004 **COP** budgets. The same prices apply to both irrigated crops and dryland crops.
Other Revenue	Estimated value of straw at $20/tonne. Straw yields indexed to grain yields. Does not include any other revenue, e.g. government transfer payments.	Estimated value of straw at $20/tonne. Straw yields indexed to grain yields. Does not include any other revenue, e.g. government transfer payments.
Gross Return	Crop Sales + Other Revenue	Crop Sales + Other Revenue
Seed	Based on respective **2004 Production Costs and Returns.** No seeding rates indicated.	Based on respective **2004 Production Costs and Returns.** No seeding rates indicated.
Fertilizer	Based on respective **2004 Production Costs and Returns.** Nitrogen cost $0.40/lb. actual N; phosphorus cost $0.28/lb. actual P; potassium cost $0.17/lb. actual K; sulphur cost $0.27/lb..	Based on respective **2004 Production Costs and Returns.** Nitrogen cost $0.40/lb. actual N; phosphorus cost $0.28/lb. actual P; potassium cost $0.17/lb. actual K; sulphur cost $0.27/lb..
Herbicide	Based on respective **2004 Production Costs and Returns, Irrigated Soils**. For forages, includes a glyphosate amortized over 4 years.	Based on respective **2004 Production Costs and Returns, Brown Soils**. For forages, includes a glyphosate amortized over 4 years.
Baling Twine/Additive	Own estimates. Indexed to yields.	Own estimates. Indexed to yields.
Crop Insurance	Excluded; assumes irrigation replaces crop insurance.	Financial cost taken from **2004 Production Costs and Returns.** No insurance for forages.
Trucking/Storage/Fees/Marketing	Based on estimated trucking costs, linked to yields. Cost per tonne hay= $4.00. Grain & oilseeds = $6/tonne.	Based on estimated trucking costs, linked to yields. Cost per tonne hay= $4.00. Grain & oilseeds = $6/tonne.
Fuel, Oil, and Lube; Machinery Repairs; Building Repairs; & Custom Work	Based on respective **2004 Production Costs and Returns, Irrigated Soils.** Diesel fuel 0.40/litre.	Based on respective **2004 Production Costs and Returns, Brown Soils.** Diesel fuel 0.40/litre.
Utilities & Misc. Expenses	Generally 50% of respective **2004 COP** estimates. Reduced because of accounting under Land Taxes, Licenses, & Insurance (see below).	Generally 50% of respective **2004 COP** estimates. Reduced because of accounting under Land Taxes, Licenses, & Insurance (see below).
Operating Interest Paid	Applied to all operating costs, excluding trucking costs. Operating interst 6% per annum. Six mo.duration, i.e. 3%.	Applied to all operating costs, excluding crop insurance and trucking costs. Operating interst 6% per annum. Six mo.duration, i.e. 3%.
Paid Labour & Benefits	Reqirement based on AAFRD **COP** estimates. Valued @$12 per hour.	Reqirement based on AAFRD **COP** estimates. Valued @$12 per hour.
Variable Costs	All of the above costs, Seed thru Paid Labour.	All of the above costs, Seed thru Paid Labour.
Land Taxes, Licenses/Insurance	Based on AAFRD **COP** estimates, adjusted to $2004.	Based on AAFRD **COP** estimates, adjusted to $2004. Allocated to crops & livestock according to respective Gross Margin contribution.
Equipment & Bldg. Interest	Linked to investment levels @2.5%/annum.	Linked to investment levels @2.5%/annum.
Building & Equipment Depreciation	Linked to investment levels, 5%/yr. for buildings; 10%/yr. for farm equipment; and 4%/year for irrigation equipment.	Linked to investment levels, 5%/yr. for buildings & 10%/yr. for farm equipment.
Capital Costs	The above costs, Interest & Depreciation. Assumes depreciation + interest = actual principal & interest payments.	The above costs, Interest & Depreciation. Assumes depreciation + interest = actual principal & interest payments.
Cash Costs	Variable Costs + Fixed Costs	Variable Costs + Fixed Costs
Total Production Costs	Variable Costs + Fixed Costs + Capital Costs + Unpaid Labour Costs	Variable Costs + Fixed Costs + Capital Costs + Unpaid Labour Costs
Gross Magin	Gross Return less Cash Costs. Sometimes called the "Contribution Margin" or "Cash Margin". Approximately equal to Value-Added in GDP calculations and economic benefit-cost studies.	Gross Return less Cash Costs. Sometimes called the "Contribution Margin" or "Cash Margin". Approximately equal to Value-Added in GDP calculations and economic benefit-cost studies.
Annual Cash Flow	Sustainable long-term annual income/acre to farm family. Gross Revenue less Total Production Costs. Also called "Family Income" and "Return to Unpaid Labour".	Sustainable long-term annual income/acre to farm family. Gross Revenue less Total Production Costs. Also called "Family Income" and "Return to Unpaid Labour".
Unpaid Family Labour	Farm family labour. Requirement based on AAFRD **COP** estimates. Valued @$12 per hour. Not included in cash costs-of-production.	Farm family labour. Requirement based on AAFRD **COP** estimates. Valued @$12 per hour. Not included in cash costs-of-production.
Return to Capital	Revenue less Variable Costs less Fixed Costs less return to unpaid family labour. Also called "Return to Investment".	Revenue less Variable Costs less Fixed Costs less return to unpaid family labour. Also called "Return to Investment".
Percent Return to Capital	Return to Capital as a percent of Total Capital investment.	Return to Capital as a percent of Total Capital investment.
Return to Equity	Gross Return less Variable Costs less Fixed Costs less Capital Costs less Unpaid Family Labour. Sometimes called "Farm Profit".	Gross Return less Variable Costs less Fixed Costs less Capital Costs less Unpaid Family Labour. Sometimes called "Farm Profit".
Family Income	Gross Revenue less Total Production Costs. Also called "Annual Cash Flow" and "Return to Unpaid Labour".	Gross Revenue less Total Production Costs. Also called "Annual Cash Flow" and "Return to Unpaid Labour".
Investment	Irrigated land, building, and farm machinery investment costs approximated from AAFRD **COPS**. Irrigation equipment cost from Table ____.	Dryland investment costs approximated from **2001 Census of Agriculture** & **Agricultural Statistics Yearbook, 2003**.
Labour	Requirements/acre estimated from AAFRD **COPS**. Valued @ $12/hour.	Requirements/acre estimated from AAFRD **COPS**. Valued @ $12/hour.
Straw	Production of cereal and pea straw estimated from AAFRD **COPS**. Approximate current prices.	Production of cereal and pea straw estimated from AAFRD **COPS**. Approximate current prices.
CROP TOTAL (column)	An average/acre based on a weighted average of all the individual crop budgets, weighed according to the projected Crop Mix.	An average/acre based on a weighted average of all the individual crop budgets, weighed according to the existing (2001)dryland Crop Mix. This excludes summerfallow (because the COPS are for stubble crops).

Attachment A-5. Economic Crop Budgets for Existing Dryland Crop Production in M.D. of Acadia $2004-05 per ac

Item	Spring Wheat #1 13.5%	Durum Wheat #1 13%	Barley	Yellow Mustard	Field Peas	Chickpeas	Alfalfa & Mixed Hay**	$2005 PER ACRE CROPS, Weighted Average	LIVESTOCK	CROPS + LIVESTOCK
	1	2	3	4	5	6	7	8	9	10
CROP MIX (excl. summerfallow) (%)	39.4%	19.7%	20.3%	5.3%	2.0%	2.0%	11.3%	100%		
(A) 1. Crop Sales	97.75	103.50	93.60	126.00	92.20	140.00	110.50			
Yield (stubble-seeded)	23.00	23.00	36.00	700.00	20.00	700.00	1.30			
Market Price	4.25	4.50	2.60	0.18	4.61	0.20	85.00			
Implicit Market Price (incl. livestock)	4.25	4.50	2.72	0.18	4.61	0.20	95.22			
2. Other Revenue	12.97	12.97	20.30	0.00	16.00	0.00	0.00			
GROSS RETURN	**110.72**	**116.47**	**113.90**	**126.00**	**108.20**	**140.00**	**110.50**	**113.82**	**9.62**	**123.44**
(B) 1. Seed	9.00	10.00	7.00	10.00	25.00	65.00	5.00			
2. Fertilizer	**23.60**	**23.60**	**23.60**	**26.30**	**5.60**	**5.60**	**13.50**			
Nitrogen	18.00	18.00	18.00	18.00	0.00	0.00	13.50			
Phosphorus	5.60	5.60	5.60	5.60	5.60	5.60	0.00			
Potassium	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Sulphur	0.00	0.00	0.00	2.70	0.00	0.00	0.00			
Micros	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
3. Herbicides	**23.50**	**23.50**	**12.00**	**24.50**	**39.50**	**29.50**	**2.50**			
Pre-Seed	4.50	4.50	4.50	4.50	4.50	4.50	2.50			
In Crop	19.00	19.00	7.50	20.00	25.00	25.00	0.00			
Pre-Harvest	0.00	0.00	0.00	0.00	10.00	0.00	0.00			
4. Baling Twine/Additive							6.37			
6. Crop Insurance	20.00	22.50	22.50	30.00	20.00	25.00	0.00	19.37		
7. Trucking/Storage/Fees/Marketing	3.76	3.76	4.70	1.90	3.27	1.90	5.20			
8. Fuel, Oil & Lube	6.30	6.30	6.30	6.30	6.30	6.30	5.25			
9. Repairs - Machinery	6.25	6.25	6.25	6.25	7.25	7.25	6.25			
10. Repairs - Buildings	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
11. Utilities & Misc. Expenses	4.00	4.00	4.00	4.00	4.00	4.00	4.00			
12. Custom Work/Special	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
13. Operating Interest Paid	2.21	2.24	1.80	2.35	2.66	3.56	1.32			
14. Paid Labour & Benefits	2.76	2.76	3.60	4.68	5.40	4.68	3.60			
OPERATING EXPENSES	**102.37**	**105.90**	**92.76**	**117.29**	**119.97**	**153.79**	**53.99**	**97.82**	**6.57**	**104.39**
(C) FIXED COSTS										
16. Land Taxes, Licenses/Insurance	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	0.64	4.00
FIXED COSTS	**3.36**	**3.36**	**3.36**	**3.36**	**3.36**	**3.36**	**3.36**	**3.36**	**0.64**	**4.00**
(D) CAPITAL COSTS										
17. Equipment & Bldg. Interest	3.63	3.63	3.63	3.63	3.63	3.63	3.63	3.63	0.69	4.33
18. Building & Equipment Depreciation	13.19	13.19	13.19	13.19	13.19	13.19	13.19	13.19	2.51	15.70
TOTAL CAPITAL COSTS	**16.83**	**16.83**	**16.83**	**16.83**	**16.83**	**16.83**	**16.83**	**16.83**	**3.20**	**20.03**
(E) CASH COSTS (B+C)	105.74	109.27	96.12	120.65	123.34	157.16	57.35	101.18	7.21	108.39
(F) TOTAL PRODUCTION COSTS (B+C+D+I)	134.57	138.10	124.95	145.76	150.97	182.27	86.18	129.72	12.63	142.35
(G) GROSS MARGIN (A-E)*	4.99	7.21	17.79	5.35	-15.14	-17.16	53.15	**12.64**	**2.40**	**15.04**
ADJUSTED GROSS MARGIN (incl. livestock	4.99	7.21	22.23	5.35	-15.14	-17.16	66.44	15.04		
(H) ANNUAL CASH FLOW (A-B-C-D)	-11.84	-9.62	0.96	-11.48	-31.97	-33.99	36.32	-4.19	-0.79	-4.98
(I) UNPAID FAMILY LABOUR (non-cash	12.00	12.00	12.00	8.28	10.80	8.28	12.00	11.70	2.22	13.93

BACKGROUND DATA:

Item	Spring Wheat #1 13.5%	Durum Wheat #1 13%	Barley	Yellow Mustard	Field Peas	Chickpeas	Alfalfa & Mixed Hay**	CROPS, Weighted Average	LIVESTOCK	CROPS + LIVESTOCK
INVESTMENT										
Land	292.00	292.00	292.00	292.00	292.00	292.00	292.00	292.00	0.00	292
Buildings	26.89	26.89	26.89	26.89	26.89	26.89	26.89	26.89	5.11	32
Machinery	118.50	118.50	118.50	118.50	118.50	118.50	118.50	118.50	22.50	141
Livestock***									55.00	55
TOTAL	437.39	437.39	437.39	437.39	437.39	437.39	437.39	437.39	82.61	520
LABOUR										
Hired Labour (hours)	0.23	0.23	0.3	0.39	0.45	0.39	0.3			
Unpaid Labour (hours)	1	1	1	0.69	0.90	0.69	1.0	12.64	2.40	15.04
Total Labour (hrs./acre/yr.)	1.23	1.23	1.30	1.08	1.35	1.08	1.30	84.0%	16.0%	100%
Rate/Hour	12.00	12.00	12.00	12.00	12.00	12.00	12.00			
Straw/Aftermath Yield (tonnes)	0.65	0.649	1.015	0.0	0.4	0	0			
Market Price ($/tonne)	20.00	20.00	20.00	0.00	40.00	0.00	118.50			
Livestock Grain Produced/Acre			0.784		0.544					
Digestable Crude Protein %	9.8%	9.8%	8.5%	25.0%	19.1%	19.1%				
Livestock Forage Produced/Acre	0.649	0.649	1.015	0.000	0.400	0.000	1.300			
Digestable Crude Protein %	0.3%	0.3%	0.3%	0.0%	10.0%	10.0%	10.4%			
TOTAL TONNES PROTEIN/ACRE	0.002	0.002	0.070	0.000	0.144	0.000	0.135	0.033		

* For methodological details, see Accompanying Notes, Attachment A-4.

** Includes 3.8% native pasture.

*** Cattle value estimate excludes calves < 1 year.

Attachment A-6. Economic Crop Budgets for Projected Irrigation Development in M.D. of Acadia* $2004-05/acre

I T E M	Feed	HRS	SWS	Alfalfa	Alfalfa	Barley	Grass	Tame	H.T.		CROPS, Wt.		CROPS +
	Barley	Wheat	Wheat	2-cut	Hay	Silage	Hay	Pasture	Canola		Average	LIVESTOCK	LIVESTOCK
	1	2	3	4	5	6	7	8	9		10	11	12
PROJECTED CROP MIX	**19.4%**	**4.4%**	**4.4%**	**45.8%**	**8.4%**	**3.8%**	**8.7%**	**1.2%**	**3.8%**		**100%**		
(A) 1. Crop Sales	247.00	276.25	320.00	585.00	450.00	352.00	400.00	280.00	350.00		444.72		
Yield	95.00	65.00	80.00	6.50	5.00	11.00	5.00	3.50	50.00				
Market Price	2.60	4.25	4.00	90.00	90.00	32.00	80.00	80.00	7.00				
Implicit Market Price (incl. livestock)	2.85	4.25	4.00	101.51	101.28	35.01	86.68	88.58	7.00				
2. Other Revenue	51.46	35.21	43.33	0.00	0.00	0.00	0.00	0.00	0.00		13.44		
GROSS RETURN	**298.46**	**311.46**	**363.33**	**585.00**	**450.00**	**352.00**	**400.00**	**280.00**	**350.00**		**458.16**	**192.36**	**650.52**
(B) 1. Seed	12.50	15.00	16.25	10.00	10.00	12.50	2.50	10.00	24.00		10.94		
2. Fertilizer	**50.10**	**50.10**	**53.50**	**22.10**	**17.00**	**50.10**	**65.00**	**65.00**	**62.90**		**36.56**		
Nitrogen	40.00	40.00	42.00	0.00	0.00	40.00	48.00	48.00	46.00		19.39		
Phosphorus	8.40	8.40	9.80	16.38	12.60	8.40	12.60	12.60	9.80		12.93		
Potassium	1.70	1.70	1.70	2.21	1.70	1.70	1.70	1.70	1.70		1.93		
Sulphur	0.00	0.00	0.00	3.51	2.70	0.00	2.70	2.70	5.40		2.31		
Micros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
3. Herbicides	**24.50**	**28.50**	**28.50**	**2.25**	**2.25**	**12.00**	**2.25**	**0.00**	**39.50**		**10.63**		
Pre-Seed	4.50	4.50	4.50	2.25	2.25	4.50	2.25	0.00	4.50		3.03		
In Crop	20.00	24.00	24.00	0.00	0.00	7.50	0.00	0.00	35.00		7.61		
Pre-Harvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
4. Baling Twine/Additive				13.00	10.00		10.00				7.66		
5. Irrigation: Pumping Costs	23.86	23.86	28.62	62.03	47.72	19.09	47.72	33.40	33.40	45.91	45.91		
6. Crop Insurance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
7. Trucking/Storage/Fees/Marketing	12.41	10.61	13.06	26.00	20.00	20.00	20.00	0.00	6.80		19.80		
8. Fuel, Oil & Lube	15.00	15.00	15.00	36.14	27.80	21.00	27.80	12.00	15.00		27.05		
9. Repairs - Machinery	20.80	20.80	20.80	40.56	31.20	20.80	31.20	8.00	20.80		31.45		
10. Repairs - Buildings	2.00	2.00	2.00	2.60	2.00	2.00	2.00	1.00	2.00		2.26		
11. Utilities & Misc. Expenses	9.00	9.00	9.00	16.25	12.50	12.50	12.50	2.25	9.00		12.96		
12. Custom Work/Special	5.00	5.00	5.00	19.50	15.00	10.00	15.00	0.00	5.00		13.48		
13. Operating Interest Paid	4.17	4.36	4.50	4.87	3.83	4.23	5.05	2.95	5.35		4.59		
14. Paid Labour & Benefits	17.88	14.40	6.96	23.09	17.76	28.08	18.00	18.00	18.00		20.01		
VARIABLE COSTS	**197.22**	**198.64**	**203.20**	**278.39**	**217.06**	**212.30**	**259.01**	**152.59**	**241.75**		**243.30**	**142.58**	**385.88**
(C) FIXED COSTS													
16. Land Taxes, Licenses/Insurance	7.31	7.31	7.31	7.31	7.31	7.31	7.31	7.31	7.31		7.31	1.69	9.00
FIXED COSTS	**7.31**	**7.31**	**7.31**	**7.31**	**7.31**	**7.31**	**7.31**	**7.31**	**7.31**		**7.31**	**1.69**	**9.00**
(D) CAPITAL COSTS													
17. Equipment & Bldg. Interest	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08		30.08	2.23	32.32
18. Building & Equipment Depreciation	67.21	67.21	67.21	67.21	67.21	67.21	67.21	67.21	67.21		67.21	7.99	75.21
TOTAL CAPITAL COSTS	**97.30**	**97.30**	**97.30**	**97.30**	**97.30**	**97.30**	**97.30**	**97.30**	**97.30**		**97.30**	**10.23**	**107.53**
(E) CASH COSTS (B+C)	204.53	205.94	210.50	285.70	224.37	219.60	266.32	159.90	249.05		250.61	144.27	394.88
(F) TOTAL PRODUCTION COSTS (B+C+D+I)	323.30	319.32	342.12	412.95	344.70	344.98	387.62	275.20	364.59		374.01	160.54	534.55
(G) GROSS MARGIN (A-E)	93.93	105.51	152.83	299.30	225.63	132.40	133.68	120.10	100.95		207.56	48.09	255.65
ADJUSTED GROSS MARGIN (incl. livestock)	117.42	105.51	152.83	374.12	282.04	165.49	167.10	150.12	100.95		255.65		
(H) ANNUAL CASH FLOW (A-B-C-D)	-3.37	8.22	55.53	202.00	128.34	35.10	36.38	22.80	3.65		110.25	37.86	148.11
(I) UNPAID FAMILY LABOUR (non-cash)	21.48	16.08	34.32	29.95	23.04	28.08	24.00	18.00	18.24		26.10	6.05	32.15

BACKGROUND DATA:

INVESTMENT													
Land	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00		600.00	0.00	600
Buildings	81.19	81.19	81.19	81.19	81.19	81.19	81.19	81.19	81.19		81.19	18.81	100
Machinery	304.46	304.46	304.46	304.46	304.46	304.46	304.46	304.46	304.46		304.46	70.54	375
Livestock												682.00	682
Irrigation Equipment	817.72	817.72	817.72	817.72	817.72	817.72	817.72	817.72	817.72		817.72		818
TOTAL	1803.37	1803.37	1803.37	1803.37	1803.37	1803.37	1803.37	1803.37	1803.37		1803.37	771.35	2575
LABOUR													
Hired Labour (hours)	1.49	1.20	0.58	1.92	1.48	2.34	1.50	1.50	1.50				
Unpaid Labour (hours)	1.79	1.34	2.86	2.50	1.92	2.34	2.00	1.50	1.52		207.56	48.09	255.65
Total Labour (hrs./acre/yr.)	3.28	2.54	3.44	4.42	3.40	4.68	3.50	3.00	3.02		81%	19%	100%
Rate/Hour	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00				
Straw/Aftermath Yield (tonnes)	2.57	1.76	2.17	0.00	0.00	0.00	0.00	0.00	0.00				
Market Price ($/tonne)	20.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00				
Livestock Grain Produced/Acre	2.068												
Digestable Crude Protein %	8.5%	9.8%	9.8%						25.0%				
Livestock Forage Produced/Acre	2.573	1.760	2.167	6.500	5.000	11.000	5.000	3.500	0.000				
Digestable Crude Protein %	0.3%	0.3%	0.3%	10.4%	10.4%	1.2%	4.0%	4.0%	0.0%				
TOTAL TONNES PROTEIN/ACRE	0.183	0.005	0.007	0.676	0.520	0.132	0.200	0.140	0.000		0.41		
											12.4 X Dryland		

* For methodological details, see Notes, Attachment A-4.

Attachment A-7. Annual Incremental Costs and Benefits of Irrigation, M.D. of Acadia $2004-05

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
CROPS:				
Gross Revenue	458.16	113.82	**344.34**	850.51
Costs-of-Production*	250.61	101.18	**149.43**	369.09
Gross Margin	207.55	12.64	194.91	481.42
LIVESTOCK:				
Gross Revenue	192.36	9.62	**182.74**	451.36
Costs-of-Production	144.27	7.21	**137.06**	338.53
Gross Margin	48.09	2.41	45.68	112.83
TOTAL:				
Gross Revenue	650.52	123.44	527.08	1301.88
Costs-of-Production	394.88	108.39	286.49	707.62
Gross Margin	255.64	15.05	240.59	594.25

* For irrigation, includes pumping costs @$45.91/acre.
For dryland, includes both the private (40%) and public (60%) cost of crop insurance.
Source: Attachment A-5 and A-6.

Attachment A-8. Projected Expenditure Patterns - Scenario 3 **$ 2005 million**

Component	Direct Expenditure Impact			
	Non-Alta	MD Acadia	Other Alta	Total
System				
Capital Phase (Years 1-3)*	5	10	82	**96**
Operational Phase (Years 4-53)*	7	27	102	**136**
Total	12	37	183	232
Agriculture Sector				
Capital Purchases**	11	6	39	**55**
Annual Costs of Production ***	35	71	248	**355**
Total	46	76	287	410
Total				
Capital Phase (Years 1-3)	5	10	82	96
Operational Phase (Years 4-53)	53	104	389	545
Total	58	113	470	642
AVERAGE/YEAR (Years 1-3)	1.6	3.2	27.2	32.0
AVERAGE/YEAR (Years 4-53)	1.1	2.1	7.8	10.9

Attachment A-9. Total GDP Impact - Scenario 3 **Cumulative Years 1-53, Undiscounted $2005 Million**

Component	Direct Expenditure Impact				Direct+Indirect GDP Impact			Average GDP Impact/Yr.		
	Non-Alta	MD Acadia	Other Alta	Total	MD Acadia	Other Alta	Total	MD Acadia	Other Alta	Total
System										
Capital Phase (Years 1-3)*	5	10	82	**96**	8	67	75	2.6	22.4	25.0
Operational Phase (Years 4-53)*	7	27	102	**136**	24	89	113	0.5	1.79	2.3
Total	12	37	183	232	32	156	188			
Agriculture Sector										
Capital Purchases**	11	6	39	**55**	4	29	34	0.1	0.6	0.7
Annual Costs of Production ***	35	71	248	**355**	54	190	244	1.1	3.8	4.9
Total	46	76	287	410	58	219	278	1.2	4.4	5.6
Total										
Capital Phase (Years 1-3)	5	10	82	96	8	67	75	2.6	22.4	25.0
Operational Phase (Years 4-53)	53	104	389	545	82	309	391	1.6	6.2	7.8
Total	58	113	470	642	90	376	466			

Source: Basic data (bold) from Table 4.2. Expenditure shares from Table 4.3; multipliers from Table 4.4.

Attachment A-10. Construction Employment - Scenario 3

Year	MD Acadia (person-yrs.)	Total Alta. (person-yrs.)
1	27	107
2	27	107
3	27	107
		0
Total	80	320

Salaries (33%) estimated at $100,000/labourer/year.

Basic Source: AE/PWSS Little Bow Studies, Appendix P.

Attachment A-11. Employment Impact -Scenario 3 **Cumulative Years 1-53**

Component	System		Ag. Sector		Total Impact	
	MD Acadia	Total Alta.	MD Acadia	Total Alta.	MD Acadia	Total Alta.
Direct "On-Site" Employment Impact (53 years)						
Capital Phase (Years 1-3)*	80	**320**	n/a	n/a	80	320
Operational Phase (Years 4-53)**	180	**200**	n/a	n/a	180	200
Total	260	520	n/a	n/a	260	520
Total Regional & Alberta Employment Impact (55 years)	Direct + Indirect					
Capital Phase (Years 1-3)*	129	1223	0	0	129	1223
Operational Phase (Years 4-53)**	157	747	1598	7593	1755	8341
Total	286	1971	1598	7593	1884	9564
Average Annual Regional & Alberta Employment Impact (53 years)		Direct + Indirect				
Capital Phase (Years 1-3=3)	43	408	0	0	43	408
Operational Phase (Years 4-53=50)	3	15	32	152	35	167

* Local = 25% total. ** Local = 90% total. Total calculated as 4 person-years X 50 years.

Source: Basic "on-site" data (bold) from Attachment A-10. Multipliers from Table 4.4. Regional/provincial estimates generated from expenditure shares in Table 4.3.

Attachment A-12. Total Income Impact - Scenario 3 **Cumulative Years 1-53, Undiscounted $2005 Million**

Component	Direct Expenditure Impact				Direct+Indirect H. Income Impact			Average Income Impact/Yr.		
	Non-Alta	MD Acadia	Other Alta	Total	MD Acadia	Other Alta	Total	MD Acadia	Other Alta	Total
System										
Capital Phase (Years 1-3)*	5	10	82	**96**	6	49	55	1.4	12.2	13.6
Operational Phase (Years 4-53)*	7	27	102	**136**	7	26	33	0.1	0.52	0.7
Total	12	37	183	232	13	75	88	1.6	12.7	14.3
Agriculture Sector										
Capital Phase **	11	6	39	**55**	2	14	16	0.0	0.3	0.3
Operational Phase ***	35	71	248	**355**	25	89	115	0.5	1.8	2.3
Total	46	76	287	410	27	103	130	0.5	2.1	2.6
Total										
Capital Phase	5	10	82	96	6	49	55	1.4	12.2	13.6
Operational Phase	53	104	389	545	34	129	164	0.7	2.6	3.3
Total	58	113	470	642	40	178	218			

Source: Basic data (bold) from Table 4.2. Expenditure shares from Table 4.3; multipliers from Table 4.4.

Attachment A-13. Regional Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 1 (13,600 acre

$ Thousands 2004-05

Project Year	INCREMENTAL COSTS: Project Capital+Eng-ineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	INCREMENTAL BENEFITS: Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Construct.-Direct + Indirect Regional GDP	System O&M - Direct + Indirect Regional GDP	Farm Capital-Direct + Indirect Regional GDP	Farm COPS.-Direct + Indirect Regional GDP	Stock Water	Recreat-ion	Other Incre. Benefits	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	18200	0	0	0	0	0	0	0	0	0	18200	0	0	1333				0	0	0	1333	-16867		
2	18200	0	0	0	0	0	0	0	0	0	18200	0	0	1333				0	0	0	1333	-16867		
3	18200	0	1111	0	0	0	0	0	0	0	19311	0	0	1333	274.5			0	0	0	1608	-17703		
4	0	301	269.6	20.1	2514.4	996.6	129.8	341.6	452.3	0	5025	1136.3	603.0		274.5	234.1	140.3	16.3	9.5	0	2414	-2611	3300	3300
5	0	350	539.2	40.3	2514.4	996.6	259.7	683.2	904.6	0	6288	2272.6	1206.1		274.5	234.1	280.6	32.5	19.2	0	4320	-1968	6600	3300
6	0	400	808.7	60.4	2514.4	996.6	389.5	1024.8	1356.9	0	7551	3409.0	1809.1		274.5	234.1	420.9	48.8	29.2	0	6226	-1325	9900	3300
7	0	449	1078.3	80.6	2514.4	996.6	519.4	1366.5	1809.2	0	8814	4545.3	2412.2		274.5	234.1	561.2	65.1	39.5	0	8132	-682	13200	3300
8	0	455	1111.0	83.0	304.8	120.8	535.1	1407.9	1864.0	0	5882	4683.0	2485.3		274.5	28.4	578.2	67.0	41.3	0	8158	2276	13600	400
9	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	41.8	0	8130	2674	13600	
10	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	42.4	0	8130	2674	13600	
11	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	43.0	0	8131	2675	13600	
12	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	43.6	0	8132	2676	13600	
13	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	44.2	0	8132	2676	13600	
14	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	44.9	0	8133	2677	13600	
15	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	45.5	0	8134	2678	13600	
16	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	46.1	0	8134	2678	13600	
17	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	46.8	0	8135	2679	13600	
18	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	47.4	0	8135	2679	13600	
19	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	48.1	0	8136	2680	13600	
20	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	48.8	0	8137	2681	13600	
21	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	49.4	0	8137	2681	13600	
22	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	50.1	0	8138	2682	13600	
23	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	50.8	0	8139	2683	13600	
24	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	51.5	0	8206	1753	13600	
25	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	52.3	0	8207	1754	13600	
26	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	53.0	0	8207	1755	13600	
27	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	53.7	0	8208	1756	13600	
28	0	455	1111.0	83.0	0	120.8	535.1	1407.9	1864.0	0	5577	4683.0	2485.3		274.5	8.1	578.2	67.0	54.5	0	8151	2574	13600	
29	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	7970	4683.0	2485.3		274.5	167.6	578.2	67.0	55.3	0	8311	341	13600	
30	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	7970	4683.0	2485.3		274.5	167.6	578.2	67.0	56.0	0	8312	341	13600	
31	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	7970	4683.0	2485.3		274.5	167.6	578.2	67.0	56.8	0	8312	342	13600	
32	0	455	1111.0	83.0	2514.4	0	535.1	1407.9	1864.0	0	7970	4683.0	2485.3		274.5	167.6	578.2	67.0	57.6	0	8313	343	13600	
33	0	455	1111.0	83.0	304.8	0	535.1	1407.9	1864.0	0	5761	4683.0	2485.3		274.5	20.3	578.2	67.0	58.4	0	8167	2406	13600	
34	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	59.2	0	8147	2691	13600	
35	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	60.1	0	8148	2692	13600	
36	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	60.9	0	8149	2693	13600	
37	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	61.8	0	8150	2694	13600	
38	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	62.6	0	8151	2695	13600	
39	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	63.5	0	8152	2696	13600	
40	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	64.4	0	8152	2696	13600	
41	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	65.3	0	8153	2697	13600	
42	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	66.2	0	8154	2698	13600	
43	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	67.1	0	8155	2699	13600	
44	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	68.1	0	8223	1770	13600	
45	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	69.0	0	8224	1771	13600	
46	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	70.0	0	8224	1772	13600	
47	0	455	1111.0	83.0	0	996.6	535.1	1407.9	1864.0	0	6453	4683.0	2485.3		274.5	66.4	578.2	67.0	71.0	0	8225	1773	13600	
48	0	455	1111.0	83.0	0	120.8	535.1	1407.9	1864.0	0	5577	4683.0	2485.3		274.5	8.1	578.2	67.0	72.0	0	8168	2591	13600	
49	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	73.0	0	8161	2705	13600	
50	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	74.0	0	8162	2706	13600	
51	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	75.0	0	8163	2707	13600	
52	0	455	1111.0	83.0	0	0	535.1	1407.9	1864.0	0	5456	4683.0	2485.3		274.5	0.0	578.2	67.0	76.1	0	8164	2708	13600	
53	-27300.00546	455	1111.0	83.0	-463.26	-2582.1	535.1	1407.9	1864.0	0	-24889	4683.0	2485.3		274.5	-203.0	578.2	67.0	77.1	0	7962	32852	13600	
PV 0%	27300	22429	54913	4019	20261	9740	25913	68178	90268	0	323021	226782	120353	4000	14000	2000	28000	3247	2737	0	401119	78098		
PV:																								
2%	$42,929	$13,181	$32,353	$2,339	$14,777	$6,917	$15,078	$39,671	$52,524	$0	$219,770	$131,959	$70,030	$3,845	$8,726	$1,535	$17,290	$1,889	$1,509	$0	$235,359	$15,589		
4%	$47,092	$8,423	$20,752	$1,477	$11,406	$5,178	$9,519	$25,046	$33,160	$0	$162,052	$83,310	$44,212	$3,700	$5,934	$1,244	$11,570	$1,193	$907	$0	$150,200	($11,852)		
6%	$47,404	$5,777	$14,307	$999	$9,234	$4,075	$6,442	$16,948	$22,439	$0	$127,626	$56,375	$29,918	$3,564	$4,341	$1,057	$8,290	$807	$588	$0	$102,962	($24,664)		

Discount Rate	B/C Ratio	NPV	IRR
2%	1.07	$15,589	
4%	0.93	($11,852)	2.94%
6%	0.81	($24,664)	
0%	1.24	$78,098	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	54600
Col.2	O&M/year ($,000) + $15/acre	251
Col.3	Diversion Pumping-Energy $,000/yr.	1111
Col. 4	Municipal Pumping-Energy $,000/yr.	83
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	344.34
Col. 13	Annual Incre. Live.Revenue/acre	182.74
Col. 14	Construction Reg. D&I GDP	4000
Col. 15	System O&M Reg. D&I GDP	14000
Col. 16	Farm Cap. Reg. D&I GDP	2000
Col. 17	Farm COPS Reg. D&I GDP	28000
Col. 18	Stockwater/acre	4.93
Col. 19	Recreation/acre (+1.4%/yr.)	2.87
Col. 20	Other Incre. Benefits	0

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, February 2005

Attachment A-14. Regional Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 2 (22,000 acre **$ Thousands 2004-05**

Project Year	INCREMENTAL COSTS: Project Capital+Engineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS
	1	2	3	4	5	6	7	8	9	10	**11**
1	26367	0	0	0	0	0	0	0	0	0	**26367**
2	26367	0	0	0	0	0	0	0	0	0	**26367**
3	26367	0	1705	0	0	0	0	0	0	0	**28072**
4	0	361	255.8	12.5	2585.0	996.6	138.1	341.6	452.3	0	**5142**
5	0	410	511.5	24.9	2585.0	996.6	276.2	683.2	904.6	0	**6392**
6	0	460	767.3	37.4	2585.0	996.6	414.3	1024.8	1356.9	0	**7642**
7	0	509	1023.0	49.8	2585.0	996.6	552.4	1366.5	1809.2	0	**8892**
8	0	559	1278.8	62.3	2585.0	996.6	690.6	1708.1	2261.5	0	**10141**
9	0	608	1534.5	74.7	2585.0	996.6	828.7	2049.7	2713.8	0	**11391**
10	0	641	1705.0	83.0	1723.4	664.4	920.7	2277.4	3015.3	0	**11030**
11	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
12	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
13	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
14	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
15	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
16	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
17	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
18	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
19	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
20	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
21	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
22	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
23	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
24	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
25	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
26	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
27	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
28	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
29	0	641	1705.0	83.0	2585.0	996.6	920.7	2277.4	3015.3	0	**12224**
30	0	641	1705.0	83.0	2585.0	664.4	920.7	2277.4	3015.3	0	**11892**
31	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**
32	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**
33	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**
34	0	641	1705.0	83.0	2585.0	0	920.7	2277.4	3015.3	0	**11228**
35	0	641	1705.0	83.0	1723.4	0	920.7	2277.4	3015.3	0	**10366**
36	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
37	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
38	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
39	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
40	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
41	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
42	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
43	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
44	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
45	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
46	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
47	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
48	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
49	0	641	1705.0	83.0	0.0	996.6	920.7	2277.4	3015.3	0	**9639**
50	0	641	1705.0	83.0	0.0	664.4	920.7	2277.4	3015.3	0	**9307**
51	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
52	0	641	1705.0	83.0	0.0	0	920.7	2277.4	3015.3	0	**8643**
53	-39550	641	1705.0	83.0	-2033.55	-4600.97	920.7	2277.4	3015.3	0	**-37542**
PV 0%	39550	31110	82096	3913	32433	15331	43413	107381	142172	0	**497400**
PV:											
2%	$62,192	$18,138	$47,741	$2,246	$23,525	$10,731	$24,914	$61,623	$81,589	$0	**$332,699**
4%	$68,222	$11,485	$30,167	$1,395	$17,912	$7,903	$15,472	$38,270	$50,670	$0	**$241,496**
6%	$68,676	$7,801	$20,473	$927	$14,253	$6,111	$10,283	$25,434	$33,675	$0	**$187,632**

Project Year	INCREMENTAL BENEFITS: Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Construct.-Direct + Indirect Regional GDP	System O&M -Direct + Indirect Regional GDP	Farm Capital-Direct + Indirect Regional GDP	Farm COPS.-Direct + Indirect Regional GDP	Stock Water	Recreat-ion	Other Incre. Benefits	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	12	13	14	15	16	17	18	19	20	**21**	**22**	19	20
1	0	0	2000				0	0	0	**2000**	**-24367**		
2	0	0	2000				0	0	0	**2000**	**-24367**		
3	0	0	2000	411.8			0	0	0	**2412**	**-25660**		
4	1136.3	603.0		411.8	299.9	143.2	16.3	9.5	0	**2620**	**-2522**	3300	3300
5	2272.6	1206.1		411.8	299.9	286.3	32.5	19.2	0	**4528**	**-1864**	6600	3300
6	3409.0	1809.1		411.8	299.9	429.5	48.8	29.2	0	**6437**	**-1205**	9900	3300
7	4545.3	2412.2		411.8	299.9	572.6	65.1	39.5	0	**8346**	**-545**	13200	3300
8	5681.6	3015.2		411.8	299.9	715.8	81.3	50.1	0	**10256**	**114**	16500	3300
9	6817.9	3618.3		411.8	299.9	859.0	97.6	60.9	0	**12165**	**774**	19800	3300
10	7575.5	4020.3		411.8	200.0	954.4	108.5	68.6	0	**13339**	**2309**	**22000**	2200
11	7575.5	4020.3		411.8	0.0	954.4	108.5	69.6	0	**13140**	**4497**	22000	
12	7575.5	4020.3		411.8	0.0	954.4	108.5	70.6	0	**13141**	**4498**	22000	
13	7575.5	4020.3		411.8	0.0	954.4	108.5	71.6	0	**13142**	**4499**	22000	
14	7575.5	4020.3		411.8	0.0	954.4	108.5	72.6	0	**13143**	**4500**	22000	
15	7575.5	4020.3		411.8	0.0	954.4	108.5	73.6	0	**13144**	**4501**	22000	
16	7575.5	4020.3		411.8	0.0	954.4	108.5	74.6	0	**13145**	**4502**	22000	
17	7575.5	4020.3		411.8	0.0	954.4	108.5	75.6	0	**13146**	**4504**	22000	
18	7575.5	4020.3		411.8	0.0	954.4	108.5	76.7	0	**13147**	**4505**	22000	
19	7575.5	4020.3		411.8	0.0	954.4	108.5	77.8	0	**13148**	**4506**	22000	
20	7575.5	4020.3		411.8	0.0	954.4	108.5	78.9	0	**13149**	**4507**	22000	
21	7575.5	4020.3		411.8	0.0	954.4	108.5	80.0	0	**13150**	**4508**	22000	
22	7575.5	4020.3		411.8	0.0	954.4	108.5	81.1	0	**13151**	**4509**	22000	
23	7575.5	4020.3		411.8	0.0	954.4	108.5	82.2	0	**13153**	**4510**	22000	
24	7575.5	4020.3		411.8	83.5	954.4	108.5	83.4	0	**13237**	**3598**	22000	
25	7575.5	4020.3		411.8	83.5	954.4	108.5	84.5	0	**13238**	**3599**	22000	
26	7575.5	4020.3		411.8	83.5	954.4	108.5	85.7	0	**13240**	**3600**	22000	
27	7575.5	4020.3		411.8	83.5	954.4	108.5	86.9	0	**13241**	**3602**	22000	
28	7575.5	4020.3		411.8	83.5	954.4	108.5	88.1	0	**13242**	**3603**	22000	
29	7575.5	4020.3		411.8	299.9	954.4	108.5	89.4	0	**13460**	**1236**	22000	
30	7575.5	4020.3		411.8	272.1	954.4	108.5	90.6	0	**13433**	**1541**	22000	
31	7575.5	4020.3		411.8	216.5	954.4	108.5	91.9	0	**13379**	**2151**	22000	
32	7575.5	4020.3		411.8	216.5	954.4	108.5	93.2	0	**13380**	**2153**	22000	
33	7575.5	4020.3		411.8	216.5	954.4	108.5	94.5	0	**13381**	**2154**	22000	
34	7575.5	4020.3		411.8	216.5	954.4	108.5	95.8	0	**13383**	**2155**	22000	
35	7575.5	4020.3		411.8	144.3	954.4	108.5	97.2	0	**13312**	**2946**	22000	
36	7575.5	4020.3		411.8	0.0	954.4	108.5	98.5	0	**13169**	**4526**	22000	
37	7575.5	4020.3		411.8	0.0	954.4	108.5	99.9	0	**13170**	**4528**	22000	
38	7575.5	4020.3		411.8	0.0	954.4	108.5	101.3	0	**13172**	**4529**	22000	
39	7575.5	4020.3		411.8	0.0	954.4	108.5	102.7	0	**13173**	**4531**	22000	
40	7575.5	4020.3		411.8	0.0	954.4	108.5	104.2	0	**13175**	**4532**	22000	
41	7575.5	4020.3		411.8	0.0	954.4	108.5	105.6	0	**13176**	**4533**	22000	
42	7575.5	4020.3		411.8	0.0	954.4	108.5	107.1	0	**13177**	**4535**	22000	
43	7575.5	4020.3		411.8	0.0	954.4	108.5	108.6	0	**13179**	**4536**	22000	
44	7575.5	4020.3		411.8	83.5	954.4	108.5	110.1	0	**13264**	**3625**	22000	
45	7575.5	4020.3		411.8	83.5	954.4	108.5	111.7	0	**13265**	**3626**	22000	
46	7575.5	4020.3		411.8	83.5	954.4	108.5	113.2	0	**13267**	**3628**	22000	
47	7575.5	4020.3		411.8	83.5	954.4	108.5	114.8	0	**13269**	**3630**	22000	
48	7575.5	4020.3		411.8	83.5	954.4	108.5	116.4	0	**13270**	**3631**	22000	
49	7575.5	4020.3		411.8	83.5	954.4	108.5	118.0	0	**13272**	**3633**	22000	
50	7575.5	4020.3		411.8	55.6	954.4	108.5	119.7	0	**13246**	**3939**	22000	
51	7575.5	4020.3		411.8	0.0	954.4	108.5	121.4	0	**13192**	**4549**	22000	
52	7575.5	4020.3		411.8	0.0	954.4	108.5	123.1	0	**13193**	**4551**	22000	
53	7575.5	4020.3		411.8	-555.6	954.4	108.5	124.8	0	**12640**	**50182**	22000	
										0		22000	
PV 0%	357184	189556	6000	21000	4000	45000	5114	4344	0	**632198**	**134798**		
PV:													
2%	$204,979	$108,782	$5,768	$13,089	$3,044	$27,405	$2,935	$2,369	$0	**$366,106**	**$33,406**		
4%	$127,299	$67,557	$5,550	$8,901	$2,432	$18,040	$1,823	$1,402	$0	**$230,061**	**($11,436)**		
6%	$84,602	$44,898	$5,346	$6,511	$2,031	$12,695	$1,211	$894	$0	**$155,109**	**($32,522)**		

Discount Rate	B/C Ratio	NPV	IRR
2%	1.10	$33,406	
4%	0.95	($11,436)	3.33%
6%	0.83	($32,522)	
0%	1.27	$134,798	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	79100
Col.2	O&M/year ($,000) + $15/acre	311
Col.3	Diversion Pumping-Energy $,000/yr.	1705
Col. 4	Municipal Pumping-Energy $,000/yr.	83
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	344.34
Col. 13	Annual Incre. Live.Revenue/acre	182.74
Col. 14	Construction Reg. D&I GDP	6000
Col. 15	System O&M Reg. D&I GDP	21000
Col. 16	Farm Cap. Reg. D&I GDP	4000
Col. 17	Farm COPS Reg. D&I GDP	45000
Col. 18	Stockwater/acre	4.93
Col. 19	Recreation/acre (+1.4%/yr.)	2.87
Col. 20	Other Incre. Benefits	0

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, February 2005

Attachment A-15. Regional Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 3 (27,000 acre

$ Thousands 2004-05

Project Year	INCREMENTAL COSTS: Project Capital+Engineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Municipal Pump Energy Costs(2500 acres)	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Product-ion Costs-Crops	Add.Farm Product-ion Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	INCREMENTAL BENEFITS: Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Construct.-Direct + Indirect Regional GDP	System O&M - Direct + Indirect Regional GDP	Farm Capital-Direct + Indirect Regional GDP	Farm COPS.-Direct + Indirect Regional GDP	Stock Water	Recreat-ion	Other Incre. Benefits	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	1	2	3	4	5	6	7	8	9	10	**11**	12	13	14	15	16	17	18	19	20	**21**	**22**	19	20
1	32033	0	0	0	0	0	0	0	0	0	**32033**	0	0	2667				0	0	0	**2667**	**-29367**		
2	32033	0	0	0	0	0	0	0	0	0	**32033**	0	0	2667				0	0	0	**2667**	**-29367**		
3	32033	0	1934	0	0	0	0	0	0	0	**33967**	0	0	2667	470.6			0	0	0	**3137**	**-30830**		
4	0	381	236.4	22.7	2419.8	996.6	140.6	341.6	452.3	0	**4991**	1136.3	603.0		470.6	248.3	142.2	16.3	9.5	0	**2626**	**-2364**	3300	3300
5	0	430	472.8	45.5	2419.8	996.6	281.2	683.2	904.6	0	**6234**	2272.6	1206.1		470.6	248.3	284.5	32.5	19.2	0	**4534**	**-1700**	6600	3300
6	0	480	709.1	68.2	2419.8	996.6	421.8	1024.8	1356.9	0	**7477**	3409.0	1809.1		470.6	248.3	426.7	48.8	29.2	0	**6442**	**-1035**	9900	3300
7	0	529	945.5	90.9	2419.8	996.6	562.4	1366.5	1809.2	0	**8720**	4545.3	2412.2		470.6	248.3	569.0	65.1	39.5	0	**8350**	**-370**	13200	3300
8	0	579	1181.9	113.7	2419.8	996.6	703.0	1708.1	2261.5	0	**9963**	5681.6	3015.2		470.6	248.3	711.2	81.3	50.1	0	**10258**	**295**	16500	3300
9	0	628	1418.3	136.4	2419.8	996.6	843.5	2049.7	2713.8	0	**11206**	6817.9	3618.3		470.6	248.3	853.4	97.6	60.9	0	**12167**	**961**	19800	3300
10	0	678	1654.6	159.1	2419.8	996.6	984.1	2391.3	3166.1	0	**12449**	7954.3	4221.3		470.6	248.3	995.7	113.9	72.1	0	**14076**	**1627**	23100	3300
11	0	727	1891.0	181.9	2419.8	996.6	1124.7	2732.9	3618.4	0	**13692**	9090.6	4824.3		470.6	248.3	1137.9	130.2	83.5	0	**15985**	**2293**	26400	3300
12	0	736	1934.0	186.0	440.0	181.2	1150.3	2795.0	3700.6	0	**11123**	9297.2	4934.0		470.6	45.1	1163.8	133.1	86.6	0	**16130**	**5007**	**27000**	600
13	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	87.8	0	**16086**	**5585**	27000	
14	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	89.0	0	**16088**	**5586**	27000	
15	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	90.3	0	**16089**	**5587**	27000	
16	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	91.6	0	**16090**	**5588**	27000	
17	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	92.8	0	**16091**	**5590**	27000	
18	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	94.1	0	**16093**	**5591**	27000	
19	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	95.5	0	**16094**	**5592**	27000	
20	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	96.8	0	**16095**	**5593**	27000	
21	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	98.2	0	**16097**	**5595**	27000	
22	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	99.5	0	**16098**	**5596**	27000	
23	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	100.9	0	**16100**	**5598**	27000	
24	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	102.3	0	**16173**	**4675**	27000	
25	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	103.8	0	**16175**	**4676**	27000	
26	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	105.2	0	**16176**	**4678**	27000	
27	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	106.7	0	**16178**	**4679**	27000	
28	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	108.2	0	**16179**	**4681**	27000	
29	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	**13918**	9297.2	4934.0		470.6	248.3	1163.8	133.1	109.7	0	**16357**	**2438**	27000	
30	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	**13918**	9297.2	4934.0		470.6	248.3	1163.8	133.1	111.2	0	**16358**	**2440**	27000	
31	0	736	1934.0	186.0	2419.8	996.6	1150.3	2795.0	3700.6	0	**13918**	9297.2	4934.0		470.6	248.3	1163.8	133.1	112.8	0	**16360**	**2441**	27000	
32	0	736	1934.0	186.0	2419.8	181.2	1150.3	2795.0	3700.6	0	**13103**	9297.2	4934.0		470.6	189.0	1163.8	133.1	114.4	0	**16302**	**3199**	27000	
33	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	**12922**	9297.2	4934.0		470.6	175.8	1163.8	133.1	116.0	0	**16290**	**3369**	27000	
34	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	**12922**	9297.2	4934.0		470.6	175.8	1163.8	133.1	117.6	0	**16292**	**3370**	27000	
35	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	**12922**	9297.2	4934.0		470.6	175.8	1163.8	133.1	119.2	0	**16294**	**3372**	27000	
36	0	736	1934.0	186.0	2419.8	0	1150.3	2795.0	3700.6	0	**12922**	9297.2	4934.0		470.6	175.8	1163.8	133.1	120.9	0	**16295**	**3374**	27000	
37	0	736	1934.0	186.0	440.0	0	1150.3	2795.0	3700.6	0	**10942**	9297.2	4934.0		470.6	32.0	1163.8	133.1	122.6	0	**16153**	**5211**	27000	
38	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	124.3	0	**16123**	**5621**	27000	
39	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	126.1	0	**16125**	**5623**	27000	
40	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	127.8	0	**16126**	**5625**	27000	
41	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	129.6	0	**16128**	**5626**	27000	
42	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	131.4	0	**16130**	**5628**	27000	
43	0	736	1934.0	186.0	0.0	0	1150.3	2795.0	3700.6	0	**10502**	9297.2	4934.0		470.6	0.0	1163.8	133.1	133.3	0	**16132**	**5630**	27000	
44	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	135.1	0	**16206**	**4708**	27000	
45	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	137.0	0	**16208**	**4710**	27000	
46	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	138.9	0	**16210**	**4711**	27000	
47	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	140.9	0	**16212**	**4713**	27000	
48	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	142.9	0	**16214**	**4715**	27000	
49	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	144.9	0	**16216**	**4717**	27000	
50	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	146.9	0	**16218**	**4719**	27000	
51	0	736	1934.0	186.0	0.0	996.6	1150.3	2795.0	3700.6	0	**11499**	9297.2	4934.0		470.6	72.4	1163.8	133.1	148.9	0	**16220**	**4721**	27000	
52	0	736	1934.0	186.0	0.0	181.2	1150.3	2795.0	3700.6	0	**10683**	9297.2	4934.0		470.6	13.2	1163.8	133.1	151.0	0	**16163**	**5480**	27000	
53	-48050	736	1934.0	186.0	-3062.17	-5952.42	1150.3	2795.0	3700.6	0	**-46563**	9297.2	4934.0		470.6	-655.1	1163.8	133.1	153.1	0	**15497**	**62059**	27000	
																							27000	
PV 0%	48050	35342	91672	8630	36535	18510	53374	129690	171709	0	**593511**	431389	228937	8000	24000	4000	54000	6176	5270	0	**761772**	**168261**		
PV:																								
2%	$75,558	$20,500	$52,913	$4,914	$26,372	$12,845	$30,388	$73,837	$97,760	$0	**$395,086**	$245,605	$130,342	$7,690	$14,959	$3,024	$32,626	$3,516	$2,854	$0	**$437,980**	**$9,838**		
4%	$82,885	$12,904	$33,154	$3,023	$19,911	$9,374	$18,697	$45,430	$60,149	$0	**$285,527**	$151,114	$80,196	$7,400	$10,173	$2,394	$21,278	$2,164	$1,676	$0	**$272,999**	**($12,527)**		
6%	$83,435	$8,711	$22,305	$1,989	$15,686	$7,177	$12,301	$29,889	$39,573	$0	**$221,066**	$99,419	$52,761	$7,128	$7,441	$1,979	$14,822	$1,423	$1,058	$0	**$182,520**	**($27,879)**		

Discount Rate	B/C Ratio	NPV	IRR
2%	1.11	$42,894	
4%	0.96	($12,527)	3.39%
6%	0.83	($38,546)	
0%	1.28	$168,261	

2004-05 COST ESTIMATES:

Col.1.	Project Construction ($,000)	96100
Col.2	O&M/year ($,000) + $15/acre	331
Col.3	Diversion Pumping-Energy $,000/yr.	1934
Col. 4	Municipal Pumping-Energy $,000/yr.	186
Col. 5	Irrigation Equip. $/acre	818
Col. 6	Other Farm Equip. $/acre	302
Col.7	Irrigation O&M $/acre/year	45.91
Col.8	Annual Crop. Prod. Costs/acre	149.43
Col.9	Annual Livestock Prod. Costs/acre	137.06
Col.10	Other	0
Col. 5	Irrigation Equip. w/o elctricity	513
Col. 7	On-Farm Irrig. O&M w/o energy	10.20

2004-05 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	344.34
Col. 13	Annual Incre. Live.Revenue/acre	182.74
Col. 14	Construction Reg. D&I GDP	8000
Col. 15	System O&M Reg. D&I GDP	24000
Col. 16	Farm Cap. Reg. D&I GDP	4000
Col. 17	Farm COPS Reg. D&I GDP	54000
Col. 18	Stockwater/acre	4.93
Col. 19	Recreation/acre (+1.4%/yr.)	2.87
Col. 20	Other Incre. Benefits	0

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, February 2005

APPENDIX B

Photographs

Photo #1: Red Deer River Valley, North Slope

Photo #2: Typical Supply Pipeline, River Valley Bank Terrain

Photo #3: Kennedy Coulee

Photo #4: Kennedy Coulee, Near Buffalo Jump

Photo #5: Potential Reservoir A1 Damsite (looking east from NE 19-23-3)

Photo #6: Potential Reservoir A1 Damsite (looking upstream)

APPENDIX C

Correspondence and Committee Meeting Minutes

mpe ENGINEERING LTD.

Minutes of Meeting

Client:	**M.D. of Acadia #34**	**File:** N:\ 22\80\001\00\MM01
Project:	**Irrigation Development - Feasibility Study**	
Date:	**October 26, 2004**	
Time:	**10:25 am**	

Attendance:	Larry Heeg	M.D. of Acadia #34 (MD)
	Gary Peers	M.D. of Acadia #34 (MD)
	Wally Chinn	Alberta Agriculture, Food and Rural Dev. (AAFRD)
	Brian Taylor	Alberta Agriculture, Food and Rural Dev.
	Trevor Helwig	Alberta Agriculture, Food and Rural Dev.)
	Randy Poon	Alberta Environment (AENV)
	Ryan Davison	PFRA
	Jeff Printz	PFRA
	Mike Breunig	MPE Engineering Ltd (MPE)
	Theo Owel	MPE Engineering Ltd (MPE)
Location:	M.D. of Acadia Boardroom – Acadia Valley	
Purpose:	Start-up Meeting (#1)	
Distribution:	All Present,	
	John Kansas	Ursus Ecosystem Management Ltd
	Patsy Cross	Madawaska Consulting
	Tom Head	Bison Historical Services Ltd
	Marv Anderson	Marv Anderson and Associates
	Alan Wright	Unitech Solutions Inc.

Action
<u>Req'd By:</u>

1.0 <u>Errors and Omissions From Previous Minutes</u>

No previous minutes.

1.1 Introductions

Gary introduced the attendees for the start-up meeting. ***Info***

1.2 Study Personnel and Responsibilities

Mike outlined the personnel involved and the preferred lines of communications. The Project Committee is essentially the group in attendance at the meeting. Mike is the MPE project leader, Theo will be involved with the main areas of mapping, development of irrigation scenarios and conceptual design. Modelling will be done by other MPE personnel.

Info

1.3 Reporting Protocol

Mike directed that all communication from sub-consultants to other committee members be routed through himself. Wally requested that all e-mail to him also be copied to Brian and Trevor. Brian is Wally's back-up in the event that Wally is unavailable. Mike suggested that for any significant e-mails, a copy always be sent to Mike and Gary.

Ryan advised that Jeff is the main PFRA contact. ***Info***

1.4 Discussion Items / Issues /Concerns

1.4.1 Water Availability

Mike mentioned that the current "water conservation objective" (WCO) for the Red Deer River is recommended by the Basin Advisory Committee (BAC) to be 50% of "in-stream flow needs" (IFN). This is a workable basis for the project for now.

In the South Saskatchewan River Basin (SSRB) regulations, irrigation development on the Red Deer River is capped at a maximum of 97,000 acres. That means that, after allowing for existing allocations and current applications, only ±20,000 acres remain available for future applications (i.e. M.D. of Acadia). The Special Areas Water Supply Project (SAWSP) application is expected to enter the stage of public hearings in December '04.

MPE will focus on modelling 50% of IFN. Gary advised that this is OK. Another level could possibly be looked into at a later date, for sensitivity analysis, if the need arises.

Any impact on the M.D. of Acadia project from the Dickson Dam operation will be identified during the AENV modelling. Wally advised that there might be a demand from Gleniffer Reservoir for a certain minimum water level.

Mike suggested that the initial model will consider diversion rates of 2 m^3/s and 4 m^3/s. ***MPE***

1.4.2 Irrigated Area Scenarios

1.4.2.1 Crop Mix / Equipment Mix

Mike mentioned that the proposed crop mix (presented at the meeting and attached to these minutes) is based on the 2003 AAFRD model. Consensus was that this crop mix appears realistic.

The irrigation equipment mix was discussed as well. Wally suggested that 50% for high-pressure pivots might be a bit too high, and that this would result in somewhat conservative estimates (3%-5%), but this equipment mix is already in the model. It was mentioned that low-pressure pivots use much less energy and less water than high-pressure, and that wheel moves are not as water efficient as pivots. The crop and equipment mix as presented and discussed will be utilized for this study.

Info

1.4.2.2 Water Use

The 2003 AAFRD model is based on demand at the farm gate. The assumption is that every assigned acre is watered (i.e. no fallow). Other irrigation districts typically assume between 3%-7% fallow. Wally provided a spreadsheet detailing water demand/consumptive use and return flows (WRMM Block 328) and he outlined the calculations regarding crop water requirement. This requirement is affected by irrigation management levels, which for purposes of this study are assumed to be "good" (meaning that farmers apply 80% of the required irrigation water for optimum crop production). The model assumes that 50% of eligible fields are fall irrigated. Annual precipitation values in the model are different for the various crops due to the varying lengths of their respective growing seasons. Wally reported that he used climatic data from the "Gridded Prairie Climate Database" which is based on a synthesized 50 km x 50 km grid. The project's climatic data is obtained from station node BE71, and this data can be obtained for the study. It was established that the water use requirements from the current AAFRD IDA model will be used for the study.

Info

Mike showed a graph illustrating the projected water deficit versus time. This graph can be used to define and highlight tolerance levels for water deficit levels. Wally pointed out that once the available water is also added to the chart, the deficits do not appear nearly as significant. For now it is assumed that a 100mm deficit experienced once in 10 years is manageable.
Ryan asked if the deficits can be identified for certain periods and the answer is yes. ***Info***

1.4.2.3 Irrigation Scenarios

Mike identified the various irrigation blocks that were presented in the 1987 Acres report. These blocks were generally based on land classification. Mike mentioned that these blocks will be further defined by excluding coulees etc.
Brian showed irrigation potential based on land classification maps (Level III). Brian had plotted pivot circles (133 acres per pivot circle) on the map. Collectively these pivots would irrigate 34,000 acres. It was noted that there does not appear to be any Land Classification for Range 1 (in Townships 24-26). Wally will check if a Land Classification was ever undertaken for this area. The Level III land classification maps are not available in digital format. Wally suggested that his department might possibly be able to digitize the plans, which would greatly assist in the Block definition. Brian had established a southwest block of about 7,000 acres, a southeast block of 3,500 acres and a southern block of 25,000 acres. It was agreed that, as a first scenario, a 10,000 acre irrigated block could encompass the southern and southwest blocks, based on economics dictating priority. The use of crown land for irrigation should be minimized if possible. Further scenarios could include 20,000 and 30,000 acre Blocks. These scenarios might be adjusted as required based on economics, land suitability and water availability.

AAFRD/MPE

1.4.4 Land Owners

Mike asked if landowners could be identified by name in the study. Consensus was that this is not important because the local population knows most landowners anyway.

Gary mentioned that certain parcels in the study area (adjacent to the river) were subject to environmentalists' concerns, mostly regarding esthetics. Theo pointed out that there are some parcels contained within the study area that are deemed to be of "paleontological significance". Gary advised that the southeast portion was affected by salinity problems and is therefore less likely to be irrigable. There are also topographical challenges and most of this land is crown land. Section 28 Twp 23 Range 1 was irrigated at one time but is no longer.

Info

1.4.6 Wind Monitoring Equipment

Mike advised that the installation of the wind monitoring facility was delayed due to equipment not all being available. It had been suggested that a site near an occupied farm residence would be desirable, to provide a bit of security. Gary said that Special Areas had engaged a specialist for the design (and subsequent installation) of a small wind farm (50 units) near the Red Deer River (about 4 miles north of the Hamlet of Buffalo). The test data for this development will no doubt be kept confidential. Consensus was that this is difficult science and that setting up a test monitor at a randomly selected site might not provide data that would easily be interpreted for the design of a larger scale power generator.

1.5 Next meeting: Tentatively scheduled for November 19, 2004 at 10:00 am to be held in Brooks.

The next meeting will focus on finalizing the irrigation blocks and discussion about water availability.

1.6 Additional Documents/Data

The various available reference documents were discussed, and a summary presented at the meeting (update attached to these minutes).

Ryan mentioned that PFRA in Regina or Hanna might have hydrology data available, possibly for any smaller dams in the region. ***Ryan***

After the meeting, Gary prepared a letter for the notification of the various property owners about the upcoming field trips by MPE and sub-consultants. Gary also provided MPE, on loan basis, with aerial photographs for the study area as well as a stereo viewer (S/N 13429).

1.7 Field trip

After lunch, the Committee toured a number of the study area sites, for information and reconnaissance purposes, including stops at the Acadia Reservoir, Kennedy Coulee (proposed storage reservoir), Red Deer River (proposed pump house site), and the site for the proposed southeast reservoir.

Minutes recorded by: Theo Owel

Based on the consensus discussions at the meeting, the following main parameters will be used for the study:

- ✓ WCO at 50% of IFN to be used for the SSRB modelling;
- ✓ Crop and equipment mix as per the attached tables;
- ✓ “On-farm” water requirement as per AAFRD 2003 WRMM modelling of Block 328;
- ✓ Three irrigation block scenarios to be:
    1. ±10,000 acres
    2. ±20,000 acres
    3. ±30,000 acres
- ✓ Priority of Irrigation Blocks to be based on land classifications, economics.

If there are any errors, omissions or discrepancies please contact MPE.

Attachments below

Municipal District of Acadia #34

Study of Irrigation Development

	Document / Data	***Authors / Source***	***Status***
1	Acadia Valley (Block 24) Level III Land Classification Report c/w 1:20,000 scale maps	Monenco Consultants for Alberta Agriculture	Received
2	Water Supply to the Special Areas Phase I Study Report (May 1987)	Acres International for Alberta Environment Planning Division	Received
3	Water-based Recreational Opportunities for Southeast Central Alberta (February 1988)	Palliser Regional Planning Comm. for The Prairie Association for Water Management	Received
4	Irrigation Development in the Red Deer River Valley (May 1988)	Acres International for Alberta Environment Planning Division	Received
5	Irrigation Development in the Red Deer River Valley – Financial Feasibility Component (September 1988)	Alberta Agriculture Resource Planning Branch	Received
6	Environmentally Significant Areas of the Lower Red Deer River (1991)	Cottonwood Consultants for Alberta Forestry, Lands and Wildlife	Received
7	Environmentally Significant Areas in the Palliser Region (March 1991)	Cottonwood Consultants for M.D. of Acadia #34	Received
8	Water Management Overview of Small Water Management Projects in the MD of Acadia (Draft July 1991)	Barlott Consulting and Hydrotech Consulting for MD of Acadia	Received
9	Co-op Pipeline Soils - Valley South Co-op (March 1999)	PFRA (from AgraSID)	Received
10	Historical Resources Impact Assessment – Water Supply Line - Valley South Co-op (May 1999)	Bison Historical Services for PFRA and Valley South Co-op Ltd.	Received
11	Comprehensive Study Report under the Canadian Environmental Assessment Act (June 1999)	PFRA for the Valley South Co-op	Received
12	Red Deer River Corridor Integrated Management Plan (March 2000)	Alberta Environment / Parkland and Bow Region Environmental Resource Committees	Received
13	MD of Acadia GIS/Mapping	Palliser Regional Municipal Services for MD of Acadia	Received
14	DEM model (4 files)	PFRA (AltaLIS 3rd party) for MD of Acadia	Received
15	Aerial photography	Palliser Regional Municipal Services for MD of Acadia	Received
16	Existing Surface Water License records (within MD of Acadia)	Alberta Environment	Received
17	Satellite Imagery	Natural Resources Canada	Received
18	Pending Water Applications	Alberta Environment	Received
19	Aerial photos and stereo viewer	M.D. of Acadia (on loan)	Received

Reference Document and Data Summary

M.D. of Acadia #34
Irrigation Development – Feasibility Study

Project Contact List

Name	Representing	Phone #	Fax #	e-mail
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Theo Owel	MPE Engineering Ltd	219-6464	250-1518	towel@mpe.ab.ca
	Sub-Consultants			
John Kansas	URSUS Ecosystem Management Ltd	282-1194	282-1194	john.kansas@ursusecosystem.com
Patsy Cross	Madawaska Consulting	282-1147	282-1686	patsy.cross@shaw.ca
Marv Anderson	Marv Anderson and Associates	464-4020	367-2355	marvanderson@telus.net
Tom Head	Bison Historical Services Ltd	283-8974	270-0575	tom@bisonhistorical.com
Alan Wright	Unitech Solutions Inc	297-5950		alan.wright@shaw.ca

Crop and Equipment Mix

CROP TYPE MIX

Crop Group	Crop Name	Crop Area (% of Total)
Cereal	Barley	19.4 %
	Wheat	8.8 %
Cereal Sub-total		28.2 %
Forage	Alfalfa (2 cut)	45.8 %
	Alfalfa Hay	8.4 %
	Barley Silage	3.8 %
	Grass Hay	8.7 %
	Tame Pasture	1.2 %
Forage Sub-total		67.9 %
Oilseed	Canola	3.8 %
Oilseed Sub-total		3.8 %
Total		100 %

IRRIGATION SYSTEM MIX

Irrigation Method	Equipment Type	Crop Area (% of Total)
Sprinkler	Hand-Move	4.6 %
	Pivot-High Pressure	50.4 %
	Pivot-Low Pressure	9.9 %
	Wheel Move	35.1 %
Flood		0 %
Total		100 %

**Above information provided by AAFRD-Irrigation Branch (Is based on work previously completed for modelling of future irrigation potential along the Red Deer River – Irrigation Block #328).

ENGINEERING LTD.

Minutes of Meeting

Client:	**M.D. of Acadia #34**	**File:** N:\ 22\80\001\00\MM02
Project:	**Irrigation Development - Feasibility Study**	
Date:	**November 26, 2004**	
Time:	**10:00 am**	

Attendance:	Larry Heeg	M.D. of Acadia #34 (MD)
	Gary Peers	M.D. of Acadia #34 (MD)
	Wally Chinn	Alberta Agriculture, Food and Rural Dev. (AAFRD)
	Brian Taylor	Alberta Agriculture, Food and Rural Dev.
	Trevor Helwig	Alberta Agriculture, Food and Rural Dev.
	Randy Poon	Alberta Environment (AENV)
	Mike Breunig	MPE Engineering Ltd (MPE)
	Theo Owel	MPE Engineering Ltd (MPE)
Location:	AAFRD Horticultural Centre Boardroom – Brooks	
Purpose:	Progress Meeting (#2)	
Distribution:	All Present,	
	Ryan Davison	PFRA
	Jeff Printz	PFRA
	John Kansas	Ursus Ecosystem Management Ltd
	Patsy Cross	Madawaska Consulting
	Tom Head	Bison Historical Services Ltd
	Marv Anderson	Marv Anderson and Associates
	Alan Wright	Unitech Solutions Inc.

Action Req'd By:

2.0 Errors and Omissions From Previous Minutes

None reported.

2.1 Business from previous meeting

1.4.2.1 Crop Mix / Equipment Mix

Consensus was that the crop mix agreed on during last meeting is OK for modelling. The equipment mix was reviewed again, and since Wally's group will be updating the IDM model data based on the latest system layout, it was agreed that the irrigation equipment mix will be revised at the same time, as follows:

Hand-move: 5%
High-pressure Pivots: 35%
Low-pressure Pivots: 50%
Wheel-moves: 10%

It is estimated that this new equipment mix will result in a slightly lower annual water demand. ***AAFRD***

2.2 WRMM Model

Mike summarized the initial WRMM modeling results, as shown on the hand-outs (which are attached to the minutes for the benefit of others not attending the meeting).

The deficit numbers in the Summary Table (i.e. 8/18) indicate the number of years in the 68-year model period (1928 – 1995) when the water deficit exceeded the established tolerance of 100mm / the number of years that there was some deficit. The bar chart then shows this result with the green bars indicating the water demand, and the red bars marking the water deficit. The base criteria was established as a rule that **the annual deficit tolerance of 100mm must not be exceeded more than 7 times over the 68-year model period**. The Summary table shows when the particular scenario did meet the criteria (green) or did not (purple).

2.3 Irrigation System Layout

MPE presented three different system layouts, showing proposed reservoir development, system conveyance works, and possible pivot layout. It was agreed that the pivot layout is not fixed, but merely a representation of what is possibly developed for irrigation. Some fine-tuning will still be undertaken. The final report might include delineation of an area recommended for irrigation development rather than a detailed layout of sprinklers, to avoid unnecessary focus on individual parcels of land. After the meeting, Wally took one of the large plots to have his staff start the modification of his model.

2.4 Irrigation Scenarios

Mike handed out a spreadsheet summary of comparison of various scenarios that MPE has established for possible irrigation development. Mike outlined the basis for this comparison, which included:

- Scenario 1a): a 10,000 acre block via gravity service from Reservoir A, or
- Scenario 1b): a 10,000 acre block pumped from a lower Reservoir A, or
- Scenario 1c): a 12,000 acre block pumped from Reservoir B on Kennedy Coulee.
- Scenario 2a): a 17,000 acre block including both sides of Kennedy Coulee, via gravity service from a higher Reservoir A, or
- Scenario 2b): a 17,000 acre block via both gravity and pumped service from Reservoir A.
- Scenario 3): a 22,000 acre block via gravity service from Reservoir A and pumped service from Reservoir B.

Mike emphasized that the costs were considered to be “order of magnitude” and were provided to demonstrate relative comparisons between the various scenarios.

Wally‘s department has digitized the Level III Land Classification plans for the study area; this data was provided to MPE and incorporated into the base data. Wally advised that the Class 4 lands (along the western part of the study area) should be excluded from the irrigated development. The use of crown land for irrigation should be minimized.

The existing Acadia Reservoir would possibly be used for discharge of tailwater/return flows from a gravity system. Gary advised that this reservoir is only about 200 acre-feet. His office has more detailed plans for this reservoir and Gary will provide these plans to MPE for reference. ***Gary***

Gary suggested that an additional number of irrigated acres (2000-3000?) might be serviced directly from the Acadia Reservoir via a pressure pipeline. These additional acres could be accommodated through increasing the "deficit tolerance" (i.e. increase from 100mm to 110mm) or by using a lower estimate of conveyance losses. These losses are currently estimated at 25%, which the committee agreed is likely too high. Wally offered that he can establish a more accurate estimate by running his IDM model with the latest MPE system layout. MPE will provide digital "shapefiles" (possibly as early as Monday) that AAFRD can incorporate into the model.

Wally offered that his department will digitize another portion of the Level III Land Classification to assist with the analysis of the additional area around Acadia Reservoir.

Mike requested input from the committee on narrowing down the scenarios for detailed investigation. Committee consensus was that the study focus on scenarios 1a), 2a) and 3 because of the advantages of lower cost for the gravity conveyance options. ***AAFRD/MPE***

2.5 Hydrology

Mike advised that MPE had nearly completed the determination of natural flows and peak flows for the study. Mike pointed out that since natural streams were not going to be used for delivery systems, the determination of flow – duration curves will not be required.

2.6 Economic Analysis

The economic analysis of the various scenarios will require a substantial number of assumptions. MPE will have Marv Anderson identify these assumptions, which will then be circulated for information and comments. ***MPE/ Marv Anderson***

2.7 Other

MPE may make another fieldtrip in the near future to further investigate a number of site conditions. ***MPE***

2.8 Next meeting:

Next meeting date is not established at this time.

The meeting adjourned around 2:30pm.

Minutes recorded by: Theo Owel

If there are any errors, omissions or discrepancies please contact MPE at (403) 250-1362.

Attachments below:

Table: Comparison of Scenarios
Table: Summary of WRMM Model Result
Charts: Initial WRMM Results – Example Deficit Charts
Graphs: Initial WRMM Results
Charts: Diversion/Storage – Optimization Chart

MD of Acadia - Irrigation Development Study
Comparison of Scenarios

Parameter	Scenario 1a)	Scenario 1b)	Scenario 1c)	Scenario 2a)	Scenario 2b)	Scenario 3	
Description	Resv. A - Gravity	Resv. A - Pumped	Resv. B - Pumped	Resv. A - Gravity	Resv. A - Combo.	Resv A - Gravity &	Reservoir B - Pumped
Irrigated Area (acres)	10,000	10,000	12,000	17,000	17,000	22,000	
Diversion System							
Rate (cms)	2	2	2 - 2.5	3 - 3.5	3 - 3.5	4 - 4.5	
Static Lift (m)	134	129	107	728	134	134	
Pipeline Length (km)	3	3	16	71	3	3	
Reservoirs						Resv. A	Resv. B
Max. Dam Height (m)	26	21	16	30	26	26	16
Live Storage (dm^3)	8000	8000	10500	14000	8000	8000	10500
Dead Storage (dm3)	7000	1000	1000	7000	7000	7000	1000
Area @ FSL (ha)	140	100	340	200	140	140	340
Earth Volume (m^3)	1,750,000	1,000,000	790,000	2,700,000	1,750,000	1,750,000	790,000
Main Delivery Systems	7000 ac. - gravity canal 3000 ac. - gravity P/L	Pumped to canals as per Scenario 1a)	Pumped to complete closed pipeline system	As per 1a), c/w syphon to gravity canal East of Ken.	Combination gravity/pumped	Gravity canal & P/L as per Scenario 1a)	Pumped from Resv. B to closed system
Distribution System	Closed Pipeline	Closed Pipeline	Closed Pipeline	Closed Pipeline	Closed Pipeline	Closed Pipeline	
Cost Estimate (ballpark)							
Supply System	$12,000,000	$12,000,000	$32,000,000	$17,000,000	$17,000,000	$16.000,000	
Reservoirs	$19,000,000	$12,000,000	$13,000,000	$26,000,000	$19,000,000	$32,000,000	
Main Delivery System	$9,800,000	$15,200,000	$12,000,000	$15,000,000	$21,000,000	$23,000,000	
Distribution System	$6,000,000	$6,000,000	$7,500,000	$10,500,000	$10,500,000	$13,500,000	
Misc. (land/utilities/etc.)	$3,000,000	$3,000,000	$4,000,000	$4,000,000	$4,000,000	$5,000,000	
Total	$49,800,000	$48,200,000	$68,500,000	$72,500,000	$71,500,000	$89,500,000	
Cost / Acre (ballpark)	$4,980	$4,820	$5,710	$4,260	$4,210	$4,100	
Additional Costs (over and above diversion pumping and O&M)	n/a	Delivery Pumping ($12 - $15/Ac/yr)	Delivery Pumping ($12 - $15/Ac/yr)	n/a	Delivery Pumping ($12 - $15/Ac/yr)	n/a	Delivery Pumping ($12 - $15/Ac/yr)

Notes:

1) Diversion Pumping energy costs would run in the order of $40 -$60 / acre / year
2) Operation & Maintenance costs would run in the order of $30 - $50 / acre / year

MD of Acadia- Irrigation Development Study

Project No. : 2280 - 001- 00
December 1, 2004

Summary of WRMM Model Result

No. of Years Deficit in Irrigation Demand **
Area =10,000 Acres

Reservoir Live Storage (Dam^3)	Diverted Flow Rate From River (m^3/s)				Comments
	1.5	2.0	4.0	6.0	
5,000		8/18	8/12		Marginal, need 2 to 4 (m^3/s)
7,100		6/12			Good at 2 (m^3/s)
10,000	9/24	5/9			Good at 2 (m^3/s)
15,000	7/16	3/5			Ok at >= 1.5 (m^3/s)
20,000	6/16				Ok, but minimal advantage

** More than 100mm deficit / Total no. of deficit years

No. of Years Deficit in Irrigation Demand **
Area =20,000 Acres

Reservoir Live Storage (Dam^3)	Diverted Flow Rate From River (m^3/s)				Comments
	1.5	2.0	4.0	6.0	
10,000			10/18	8/15	OK with 6 (m^3/s)
15,000			8/14	8/11	Minimal advantage of 6 (m^3/s) over 4 (m^3/s)
20,000			7/10	4/8	Good at 6 (m^3/s), marginal at 4 (m^3/s)
25,000			5/9		Good at 4 (m^3/s)
30,000		37/59			Not feasible at 2 (m^3/s)

** More than 100mm deficit / Total no. of deficit years

No. of Years Deficit in Irrigation Demand **
Area =30,000 Acres

Reservoir Live Storage (Dam^3)	Diverted Flow Rate From River (m^3/s)				Comments
	1.5	2.0	4.0	6.0	
20,000			24/38	10/18	No good
25,000				8/15	Marginal at 6 (m^3/s)
30,000			21/33	7/13	Not much change from 25, 000 Dam^3 at 6 (m^3/s)
35,000			20/33	6/12	Good at 6 (m^3/s)

** More than 100mm annual deficit / Total no. of deficit years

Criteria: Must not have >/=100mm annual deficit more than 7 times over model period (1 in 10)

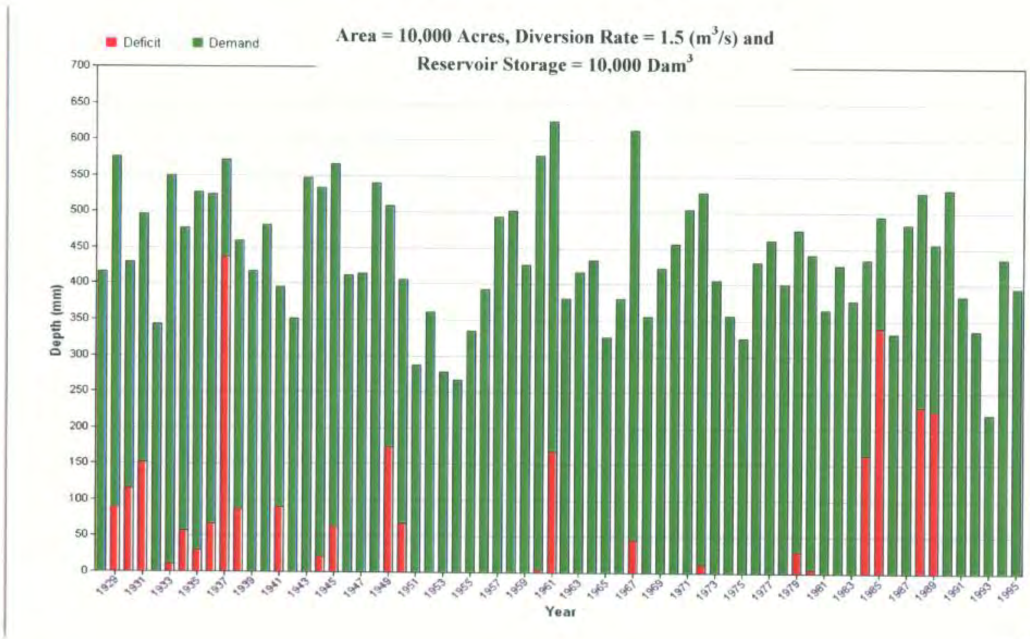
Does not meet criteria

Meets criteria

Assumptions in Model:

- Model is based on 1928 - 1995 period of record (68 years)
- 25% of conveyance losses and return flow has been considered in the model
- Shallow lake evaporation and precipitation has been considered for the reservoir
- Reservoir seepage losses and diversion shutdown for high diversion losses have not been considered

MD of Acadia - Irrigation Development Study
Initial WRMM Results - Example Deficit Charts



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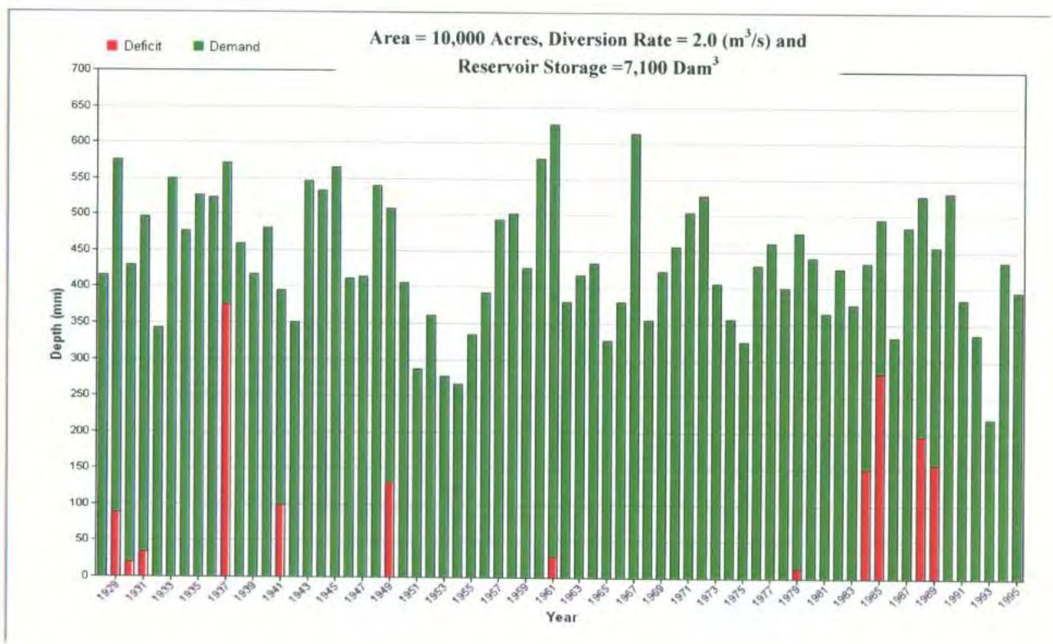
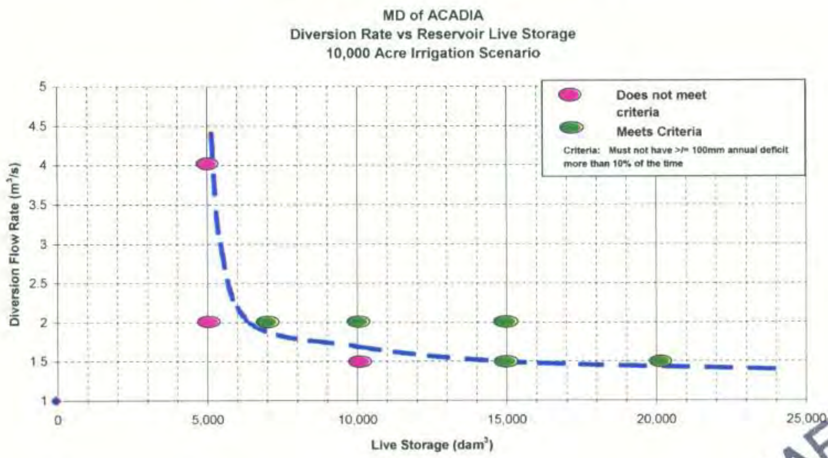
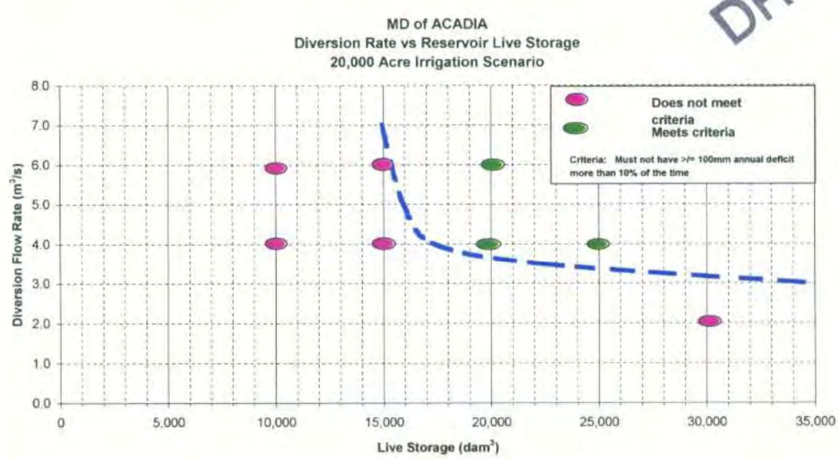
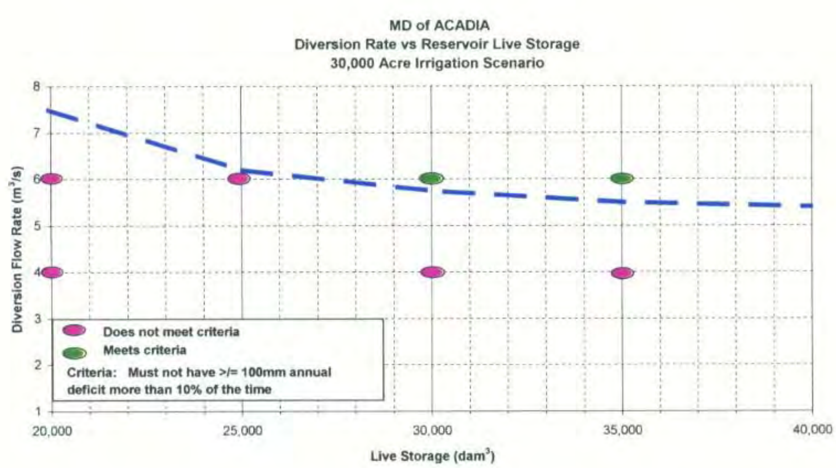


Initial WRMM Summary Results

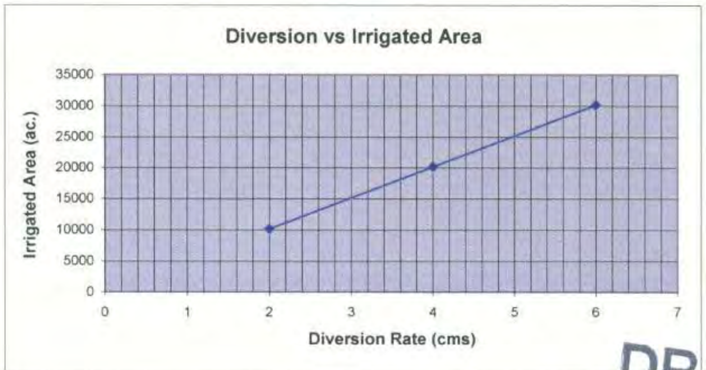






Initial WRMM Results
Diversion/Storage - Optimization Chart

Irrigated Area (Ac.)	Diversion Rate (cms)	WRRM - Reservoir Live Storage (dm3)	Reservoir Losses (dm3-10% of live)	Emergency Storage for High Sediment Loading (dm3 - 7 days)	Total Live Storage Required (dm3)
10000	2	6500	650	1210	8400
20000	4	17500	1750	2419	21700
30000	6	27000	2700	3639	33300



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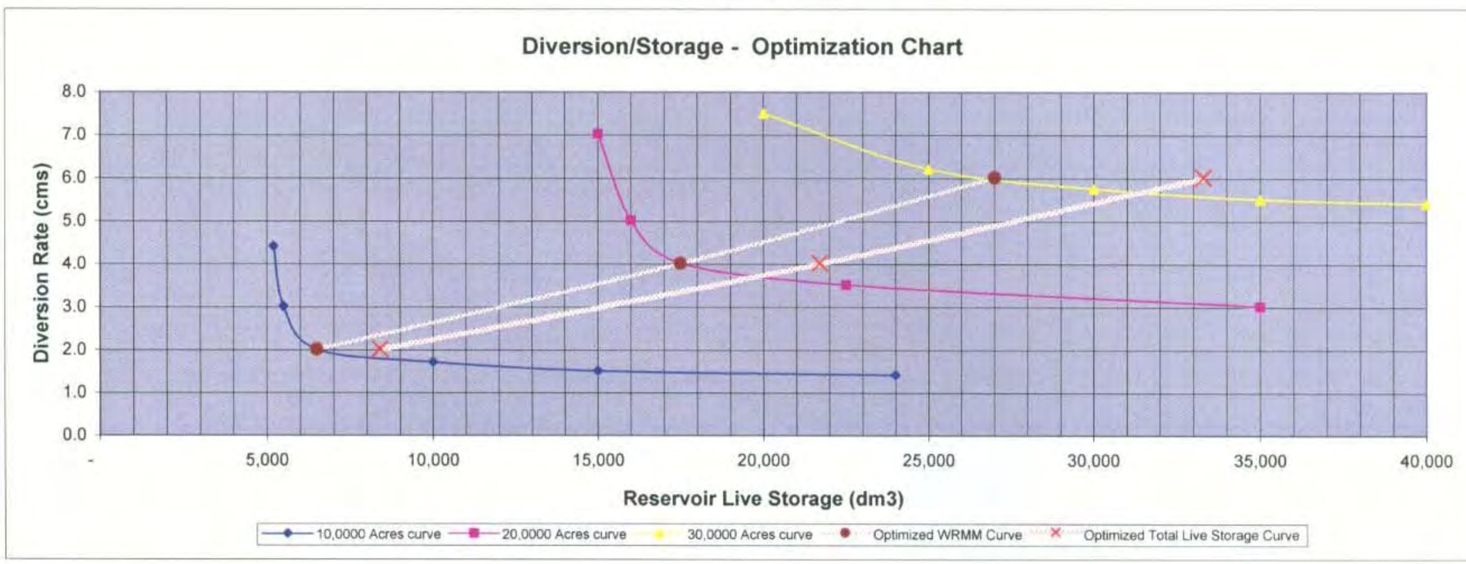


APPENDIX D

Hydrology

Appendix D

Hydrology

1.0 General

The MD of Acadia is a relatively dry area of the province that experiences significant dry periods (minimal or no runoff). In discussions with MD staff, runoff can be considerable when it occurs (usually spring snowmelt) but several years can pass without any measurable runoff at all. This is supported by the historic records of the only Water Survey Canada (WSC) station in the MD (Kennedy Coulee near Acadia Valley - #05CK006), as shown on Table D1. This station is located on Kennedy Coulee, immediately below the Acadia Recreational Reservoir. The station's gross drainage area (GDA) is 939 km^2, while the effective drainage area (EDA) is 235 km^2. Annual historical runoff volumes for Kennedy Coulee are negligible, (less than 500 dam^3) 80% of the time. Zero run-off years occurred for five consecutive years in a row between 1998 and 2002. High runoff events do occur occasionally however, with the highest recorded maximum instantaneous flow on record being 47.3 m^3/s in 1997, with a total runoff volume that spring of 8,570 dam^3.

Table D1
Kennedy Coulee Near Acadia Valley (WSC 05CK006)

Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Annual Discharge (dam^3)
1982	----	0.728 on Mar 29	0.000B on Mar 01	440
1983	----	0.179B on Mar 14	0.000B on Mar 01	59.8
1984	----	0.000B on Feb 28	0.000B on Feb 28	0.000
1985	----	9.60B on Apr 02	0.000B on Mar 01	3.320
1986	----	0.004 on Feb 26	0.000B on Feb 18	0.346
1987	----	0.306 on Mar 26	0.000B on Feb 18	132
1988	7.00A at 11:00 MST on Jun 09	5.57 on Jun 09	0.000 on Feb 17	851
1989	----	0.556 on Apr 03	0.000 on Mar 01	107
1990	----	0.000 on Feb 26	0.000 on Feb 26	0.000
1991	----	0.000A on Feb 19	0.000A on Feb 19	0.000
1992	----	0.000B on Feb 24	0.000B on Feb 24	0.000
1993	----	0.800 on Jul 28	0.000B on Feb 24	109
1994	----	5.99B on Mar 17	0.000B on Mar 01	1 660
1995	----	0.000 on Feb 22	0.000 on Feb 22	0.000
1996	----	0.415B on Mar 19	0.000B on Feb 27	93.7
1997	47.3 on Mar 26	33.5 on Mar 27	0.000B on Feb 24	8 570
1998	----	0.000 on Feb 25	0.000 on Feb 25	0.000
1999	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000
2000	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000
2001	----	0.000 on Mar 01	0.000 on Mar 01	0.000
2002	0.000 at 00:00 MST on Mar 01	0.000 on Mar 01	0.000 on Mar 01	0.000

2.0 Natural Flow Methodology

Surface hydrology in this area is sporadic at best; therefore, runoff cannot be relied on to meet irrigation demand requirements and therefore has little or no impact on the River diversion or reservoir storage requirements for the three development scenarios. For the purposes of this study however; natural spring runoff flows at the Acadia Recreational Reservoir and Reservoir A1 were determined and incorporated into the WRMM model for the determination of the annual irrigation water balance and diversion requirements from the Red Deer River for each development scenario.

Flow records from the Kennedy Coulee WSC station (Kennedy) indicate that 94% of the runoff recorded between 1982 and 2003 occurred in March and April, and thus represent spring runoff (snow melt). Only twice over the 22 year record did summer rainfall result in any measurable runoff. This indicates that summer precipitation events would have negligible impact on water balance modelling for the development scenarios. Therefore, only the naturalized volumes resulting from spring runoff were developed for this study.

The surface water licenses for the drainage area contributing to Kennedy Coulee were obtained from AENV. A total of 13 licenses contribute to the Kennedy station with a total annual consumptive use of 19.1 dam^3. The license information is tabulated in Table D2.

The recorded spring runoff volumes for the Kennedy station (1982 – 2003) were naturalized by adding the annual consumptive use from the licenses to the recorded spring runoff volume. To provide flows for years when flow records were not available for the Kennedy station (1928 – 1921), naturalized runoff values were determined through a multiple regression analysis (i.e. developing a correlation between the recorded runoff volumes with the previous fall and winter recorded precipitation records). The resulting correlation was relatively poor (R=0.61) due to the lack of available records in the area. Other correlations were considered with similar (or worse) results. There are numerous factors and assumptions that could induce significant error in the development of naturalized flows for this area. In addition, the results have little or no impact on the system infrastructure requirements or the project's feasibility. Therefore; the correlation method as described above was utilized for this study to determine natural runoff volumes at the Kennedy station for the years when flow records were not available. The correlation equation used is as follows:

$$\text{Natural Spring Runoff Volume } (m^3) = (109{,}554 * P1) + (23{,}930*P2) - 2{,}453{,}573$$

P1 = previous year October precipitation (mm) - (Empress Station)
P2 = previous November to April precipitation (mm) - (Empress Station)

Natural flows for the WRMM modelling were derived for the period from 1928 to 1995, by converting the naturalized volumes to flows, over a three week period in the spring

(Mid-March to early-April) based on the average distribution of recorded flows at the Kennedy station. Since the Acadia Recreational Reservoir is located immediately upstream of the Kennedy station, the naturalized spring runoff values obtained for the station were utilized.

It was determined that there were no current water licenses within the watershed contributing to Reservoir A1. Therefore, natural spring runoff volumes at this location were transferred from the Kennedy station via the ratio between drainage areas.

A summary of the natural spring runoff volumes (annual) is provided in Chart D1.

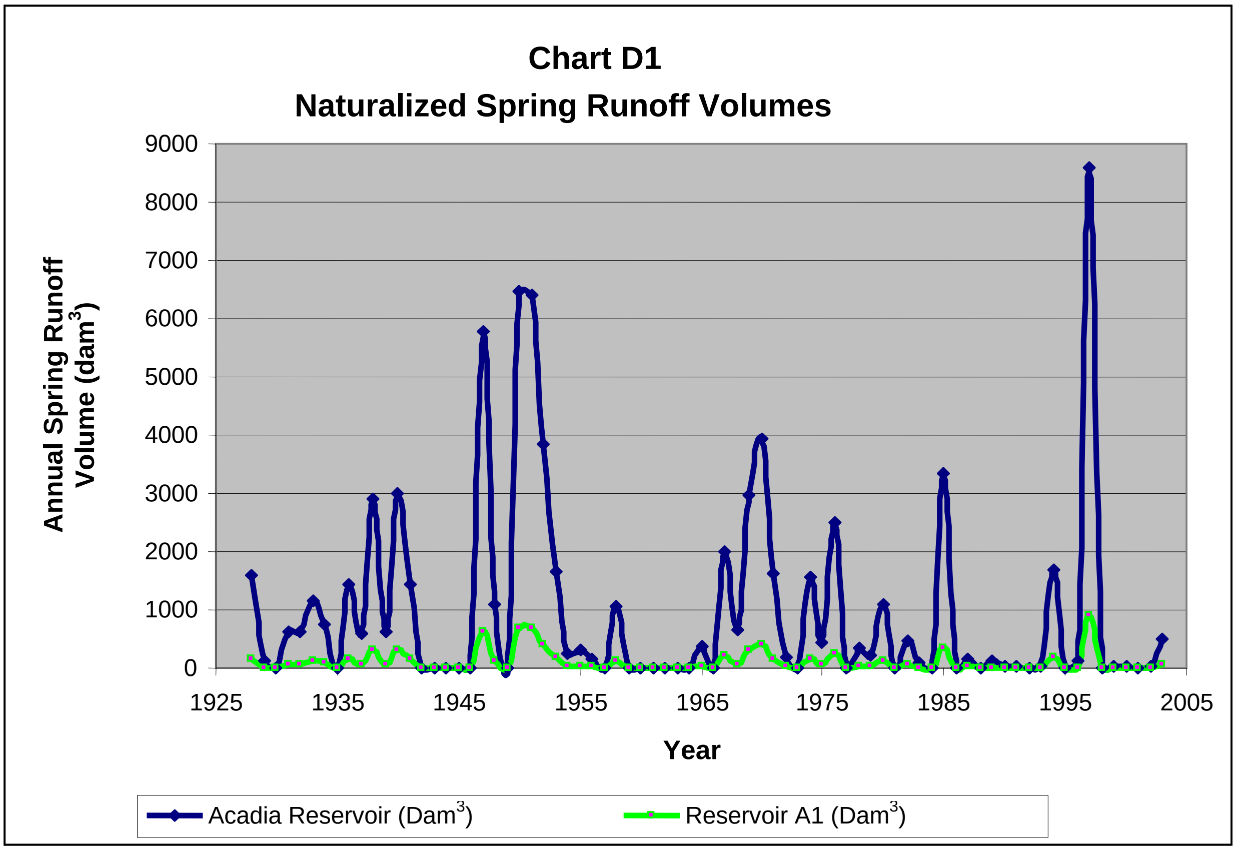


Table D2
Water Licenses Above Kennedy Coulee Gauge

APV ID	Activity	Approval Name	CONSUMPTIVE USE	LOSSES	RETURN FLOW	IRRIGABLE AREA	Location Qtr	Sec	Twp	Rge	Mer	Lat.	Long.	APPROVED DATE	Priority No (yyyy-mm-dd)	Water Body Name
40716	Irrigation -- Crop (Grain)	GOOD, WR, 08838	7400	0	0	5.25	SW	30	25	1	4	51.163	-110.137	17-Sep-82	1950-10-16-01	Red Deer River
41147	Agricultural -- Stockwatering	MEERS, WR, 08182	1230	4930	0	0	SW	19	26	1	4	51.227	-110.141	10-Jun-86	1948-07-12-03	Red Deer River
43462	Agricultural -- Stockwatering	LEMKE, WR, 04234	1230	2470	0	0	NE	8	26	1	4	51.207	-110.103	23-Sep-85	1937-11-15-02	Red Deer River
41429	Agricultural -- Stockwatering	SALMON, WR, 07727	1230	6170	0	0	SW	20	26	1	4	51.229	-110.118	19-Dec-50	1946-11-12-01	Berry Creek
35642	Recreation -- Fairgrounds/Entertainment Centres, etc	MUNICIPAL DISTRICT OF ACADIA, WR, 14773	0	61670	0	0	SW	5	25	2	4	51.096	-110.258	03-Nov-86	1984-03-29-02	Kennedy Creek
44172	Agricultural -- Stockwatering	SKAPPAK, WR, 02968	1230	6170	0	0	SE	11	25	2	4	51.112	-110.175	27-Jan-86	1936-07-02-02	Red Deer River
44092	Agricultural -- Stockwatering	MANTIE, WR, 03099	1230	1230	0	0	NE	1	25	2	4	51.108	-110.152	13-Sep-82	1936-08-19-07	Red Deer River
44313	Agricultural -- Stockwatering	MCGHEE, WR, 02738	1230	2470	0	0	NW	12	25	2	4	51.119	-110.156	30-Mar-83	1938-09-16-01	Red Deer River
43485	Agricultural -- Stockwatering	GIBSON, WR, 04191	1230	1230	0	0	SE	16	25	2	4	51.125	-110.215	07-Apr-86	1938-01-19-02	Red Deer River
43108	Agricultural -- Stockwatering	KNAPIK, WR, 04896	620	620	0	0	SW	15	25	2	4	51.126	-110.209	15-Aug-83	1938-08-10-02	Red Deer River
42586	Agricultural -- Stockwatering	NIWA, WR, 05964	1230	6170	0	0	NW	13	25	2	4	51.137	-110.165	15-Sep-87	1940-05-17-01	Red Deer River
39810	Agricultural -- Stockwatering	STOLZ, WR, 10054	0	19740	0	0	SW	26	25	2	4	51.159	-110.189	14-Jul-83	1981-06-02-01	Red Deer River
39811	Agricultural -- Stockwatering	STOLZ, WR, 10054	1230	11100	0	0	SW	26	25	2	4	51.158	-110.189	14-Jul-83	1959-07-20-02	Red Deer River

3.0 Flood Hydrographs

3.1 Peak Flow Estimates

Peak flow estimates and hydrographs were established for Reservoir A1 and the Acadia Recreational Reservoir to assist in assessing infrastructure requirements in these locations.

The lack of stream flow stations, coupled with the short period of available record and numerous zero runoff years made it difficult to determine peak flow estimates for this area. A number of hydrological methods and analyses were completed, including a regional analysis utilizing five WSC stations from the general area; a single station analyses with Kennedy Coulee recorded data; a single station analysis with Kennedy Coulee extended with Alkali Creek; and a single station analysis on Alkali Creek.

The results of these analyses were sporadic and inconclusive. For the purpose of this study, the single station analysis of the Kennedy station, with the period of record extended to 41 years using the Alkali Creek station, was selected to generate peak flood estimates for the 1:100 and 1:1,000 year return periods. A linear regression analysis using the Alkali Creek maximum daily flows was utilized to extend the Kennedy station maximum daily flow data to 41 years. The regression formula used is shown below and had a correlation coefficient of R=0.92:

$$\text{Kennedy } Q_{(\text{max. daily})} = 1.869 * \text{Alkali } Q_{(\text{max. daily})} + 0.042$$

To obtain maximum instantaneous peak discharges for Kennedy Coulee, another regression equation was utilized, as shown below. The regression was based on 23 years of common flow data and produced a reasonable correlation coefficient (R=0.98):

$$\text{Max } Q_{(\text{instant})} = 1.61 * \{Q_{(\text{max. daily})}\}^{\wedge 1.018}$$

The resulting 41 years of extended peak instantaneous discharge data for Kennedy Coulee included 10 years of record with zero flows. A Pearson III flood frequency analysis was used on the extended data to develop peak flows for Kennedy Creek for various return periods. The resulting values were adjusted for zero flow years using a method recommended in the 2001 Alberta Transportation Flood Frequency Guidelines (IAWCD 1982, Stedinger et al 1992):

$$Qadj = Po + (1-Po) * Q$$

Qadj = Peak flow adjusted for zero flow years
Po = Probability of zero flows (10 / 41)
Q = Non-adjusted peak flow for a specific return period

The resulting adjusted peak flow estimates for the Kennedy WSC station were utilized for Acadia Recreational Reservoir and transferred to Reservoir A1 (using a drainage area ratio raised to exponent of 0.8).

3.2 Peak Volume Estimates

Spring flood volume records for the Kennedy Coulee station were extended using a linear regression of the recorded volumes with the adjusted peak spring flows developed for Kennedy Coulee in Section 3.1. The resulting regression equation produced a good correlation coefficient (R=0.99):

$$\text{Flood Volume} = 178{,}016.4\ (\text{Max. Inst. Q})^{\wedge 1.002}$$

3.3 Summary of Results

The peak flow estimates and flood volumes for the 1:100 and 1:1,000 year return periods for the Acadia Recreational Reservoir and Reservoir A1 are provided in Tables D3 and D4. The selected flood frequency curve is provided in Chart D2.

Table D3
Acadia Recreational Reservoir (GDA = 939 km^2)

Return Period	Peak Flow Estimates		Flood Volume
	Max. Daily	Max. Instantaneous	
1: 100 yr.	60 m^3/s	105 m^3/s	18,900 dam^3
1:1,000 yr.	96 m^3/s	169 m^3/s	30,400 dam^3

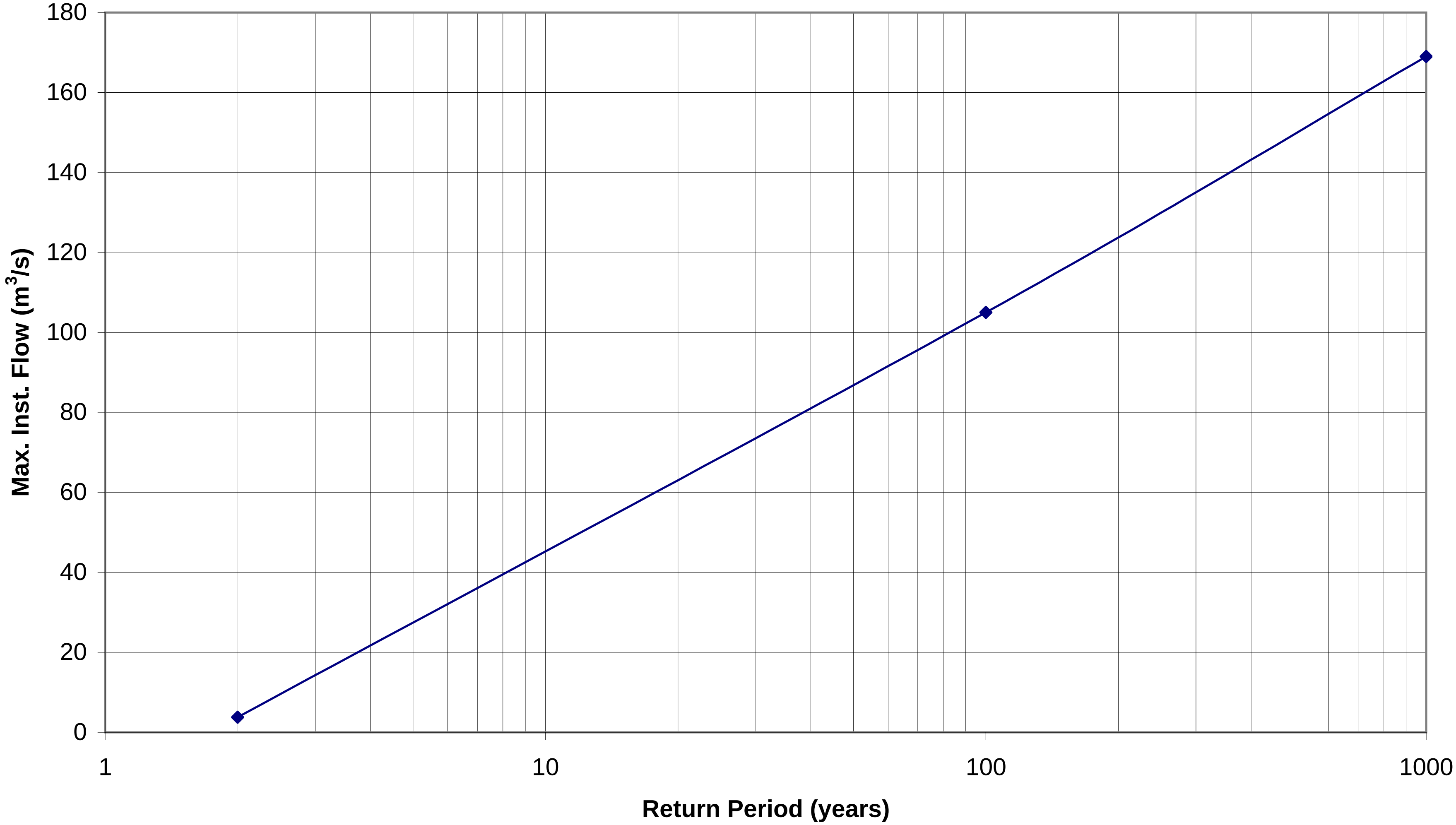
Table D4
Reservoir A1 (GDA = 99.5 km^2)

Return Period	Peak Flow Estimates		Flood Volume
	Max. Daily	Max. Instantaneous	
1: 100 yr.	10 m^3/s	17.4 m^3/s	3,115 dam^3
1:1,000 yr.	16 m^3/s	28.1 m^3/s	5,040 dam^3

The highest flow on record for the Kennedy Creek WSC station is 47.3 m^3/s (March 26, 1997). This flow was considerably higher than any of the other recorded flows over the 21 year record and equates to about a 1:15 year return period based on Chart D2.

MPE completed a hydrology analysis for the Carolside Reservoir (located on Berry Creek, approximately 100 km west of Acadia, in 2002. The 1:100 and 1:1,000 year peak flows were transposed to the Kennedy Creek WSC station drainage area (Acadia Recreational Reservoir). The peak flows determined in Table D2 were about 15-20% higher than those derived for Carolside Reservoir. This is reasonable, considering that Carolside has considerable storage within its drainage basin, upstream of the reservoir. Therefore; the peak flow estimates utilized for this study appear reasonable.

Chart D2
Selected Flood Frequency Curve



3.4 Hydrographs

The hydrograph shape was generated using an AENV standard dimensionless hydrograph created for Prairie Streams:

$$Tp = (D*A) * (Qp*129.57)$$

Tp = time to peak
D = runoff depth
A = drainage area
Qp = max. instantaneous peak discharge

The 1:100 year and 1:1,000 hydrographs for the Acadia Recreational Reservoir and Reservoir A1 are provided in Chart D3 to D6.

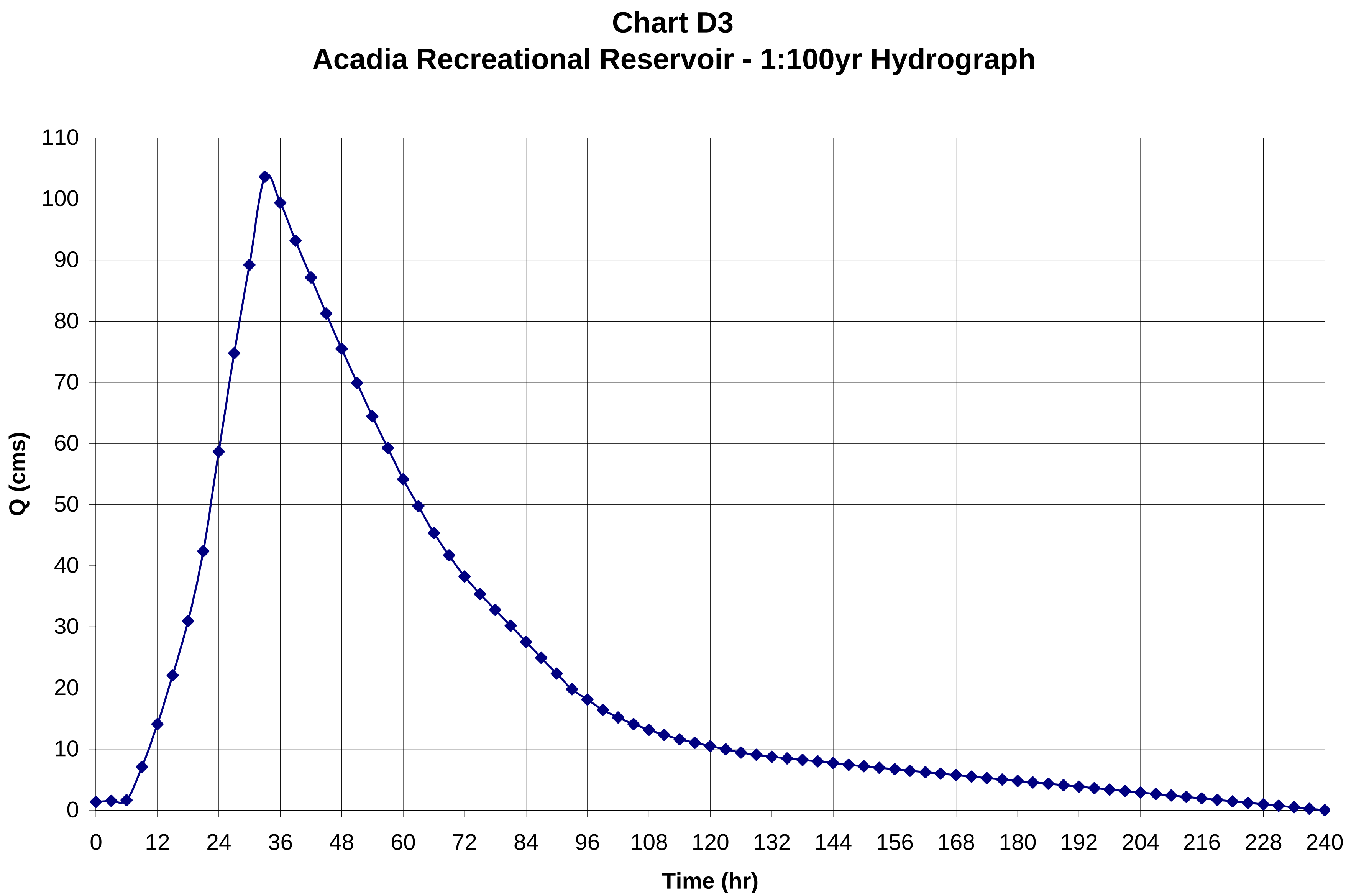


Chart D3
Acadia Recreational Reservoir - 1:100yr Hydrograph
Q (cms)
Time (hr)
0
10
20
30
40
50
60
70
80
90
100
110
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
216
228
240

Chart D4
Acadia Recreational Reservoir - 1:1,000yr Hydrograph

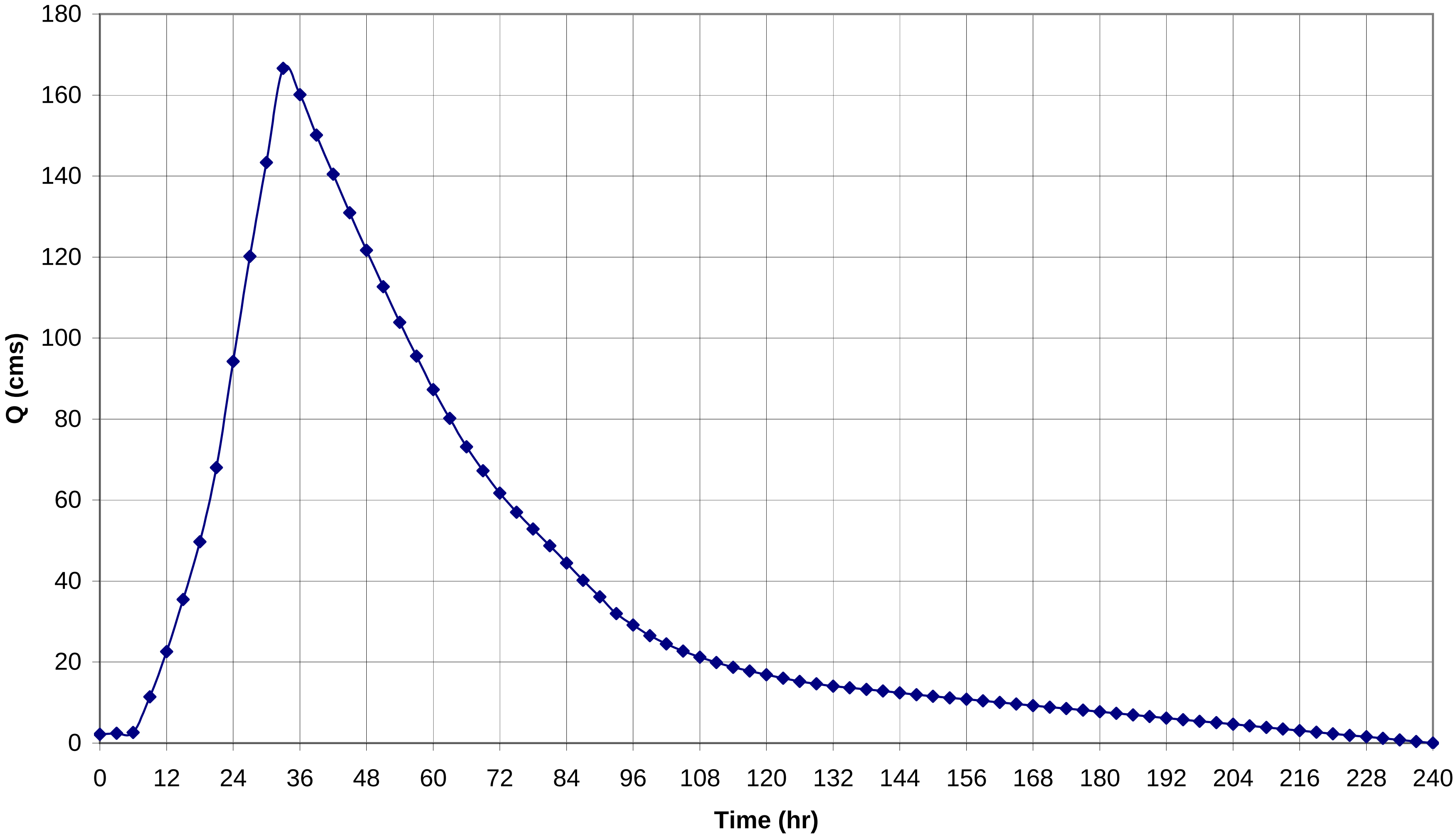


Chart D5
Reservoir A1 - 1:100yr Hydrograph

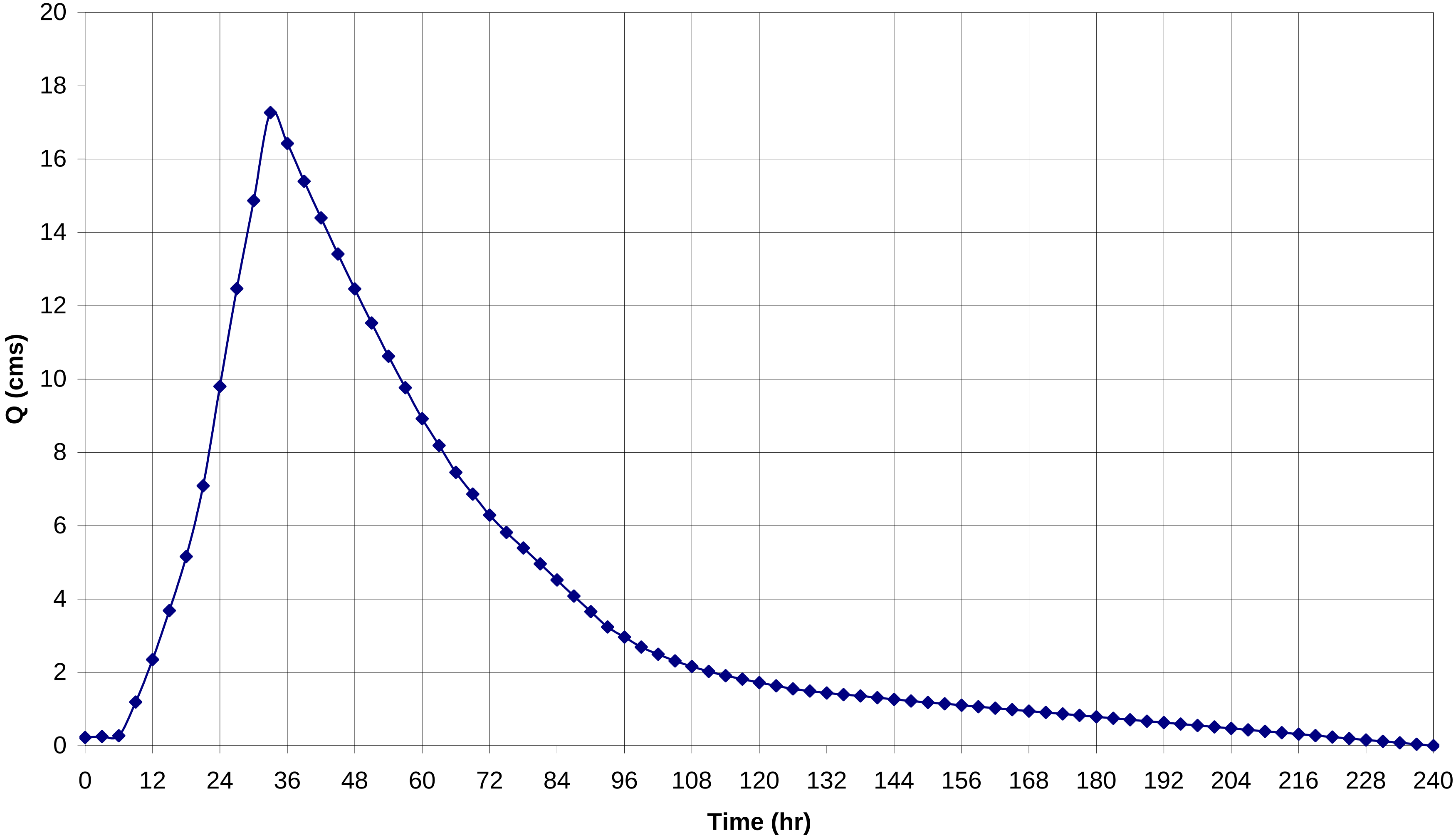
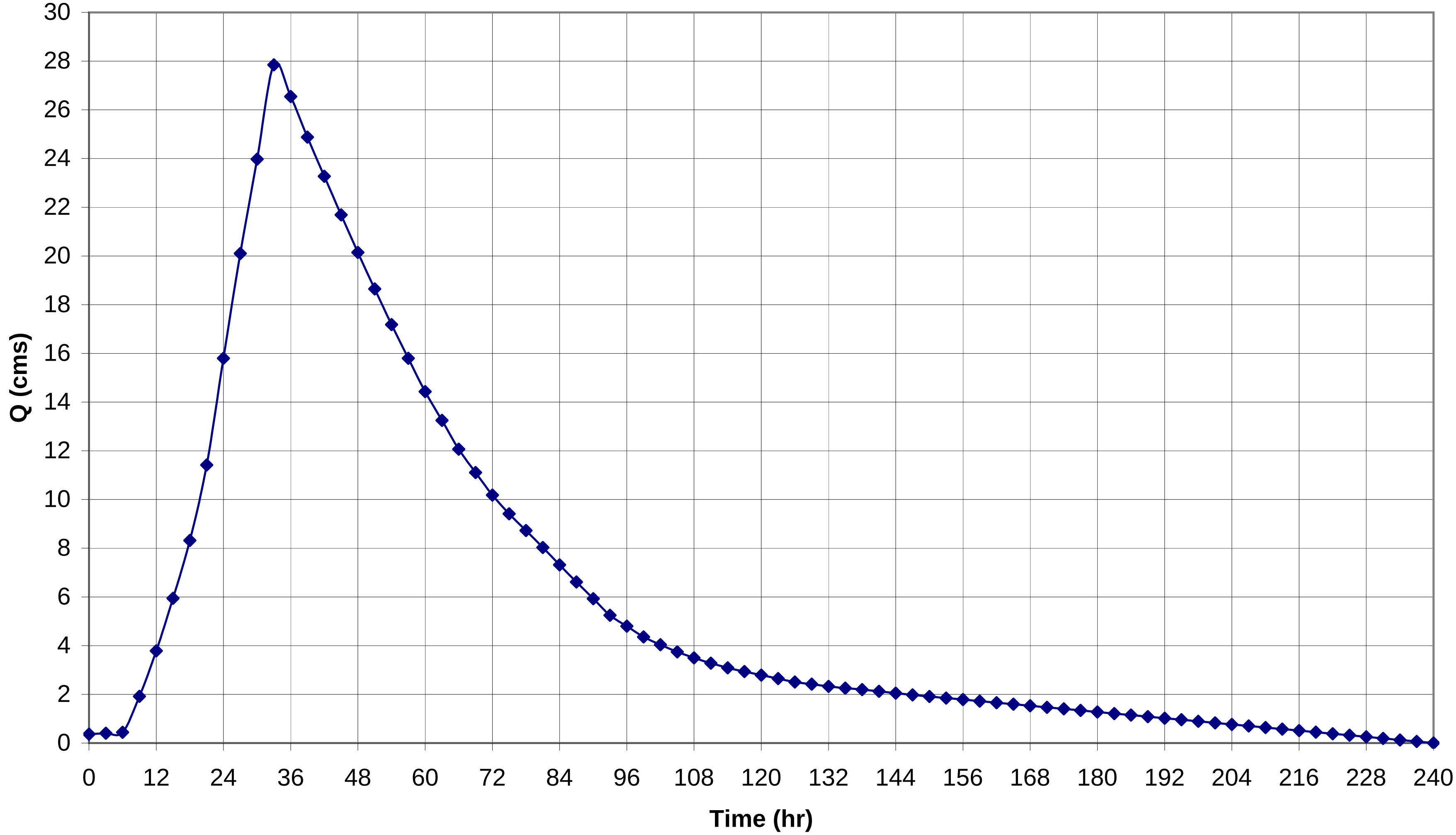


Chart D6
Reservoir A1 - 1:1,000yr Hydrograph



APPENDIX E

WRMM Simulations

Appendix E
WRMM Simulations

1.0 Introduction

The surface water runoff in this area varies considerably from year to year and cannot be relied on to meet (in whole or part) the irrigation demand requirements for any of the development scenarios. Therefore; it was assumed that the primary source of water for this project is diversion from the Red Deer River.

This appendix outlines the assumption, methodology and results of the numerical modelling (WRMM) for the three development scenarios investigated as part of this study.

2.0 Supply Flows

In order to determine the impacts that the proposed irrigation development scenarios would have on water availability in the Red Deer River, AENV completed simulations using their South Saskatchewan River Basin (SSRB) Water Resources Management Model (WRMM).

The SSRB simulations incorporated the following information / assumptions:

1) The model included all existing water license allocations, as well as any current applications, within the river basin (updated to 2004). This included the SAWSP application for 76,500 dam^3, as well as 8,093 ha. (20,000 acres) of irrigation development for the Deadfish/Sheerness irrigation project. However, modelling did not evaluate the impact of this project on existing junior licensees relying on Dickson Dam storage. This should be assessed as part of the water licenses approval process.

2) The WCO (water conservation objective) that was used in the SSRB modelling for this study was the ***50% IFN***. This is the WCO recommended by the Basin Advisory Committee (BAC) for the Red Deer River. This is further defined as:

   i) For every reach in the Red Deer River from Dickson Dam to the Saskatchewan border, the weekly instream flow requirement was set to 50% of the flow value in that week that provides **full riverine ecosystem protection**; and
   ii) A minimum flow of 16 m^3/s being released from Dickson dam year-round (every week).

   Full riverine ecosystem protection *is defined as: "a high level of protection" for four instream components (Water Quality; Fish Habitat; Riparian Vegetation and Channel Maintenance).*

3) The modelling took into account apportionment requirements to Saskatchewan – in particular the additional flow required from the Red Deer River when the Bow and

Oldman River contributions are low. However, the modelling did not assess the impact on existing junior licensees relying on Oldman Dam storage as a result of apportionment requirements to Saskatchewan. This should be assessed as part of the water license approval process.

4) A modest amount of Gleniffer Reservoir storage (between FSL and the Minimum Fill Curve) was made available to all modelled allocations (existing licenses and future allocations). Thus, water availability to the MD of Acadia irrigation project is somewhat improved by the use of Government owned storage in the current modelling.

As part of the initial "optimization" process completed for this study, model runs assuming constant diversion rates of 2, 4 and 6 m^3/s were completed. The results from these runs were utilized to optimize the water availability in the River with the diversion rate and off-stream storage requirement for various irrigation development scenarios. For modelling purposes, a weighted annual demand deficit of equal to or greater than 100mm, was assumed to be acceptable no more than 10% of the time (i.e. no more than 6 times in 68 years of model years). This deficit criteria is similar to what was used for SAWSP and other irrigation block modelling used for SSRB planning. The results of this initial optimization process are summarized in meeting minutes MM02, Appendix C. In short, it was determined that the optimal river diversion rate was 2 m^3/s for Scenario 1 (5464 ha); and 4 m^3/s for Scenarios 2 & 3 (8,904 ha & 10,927 ha).

A project WRMM was setup for each of the three development scenarios, incorporating the assumptions and criteria as outlined in the Section 3 of this appendix. Initial runs utilized the time series values of available supply flows from the River as established from the SSRB simulations. This supply flow information assumed a constant diversion rate. However, this constant diversion rate is often higher that the demand (i.e. the reservoirs are full and the diversion rate is often higher than the flow rate required to meet irrigation demand). Therefore, any available, but unused water from the River was transferred at the supply point to a separate file (Diversion Channel 10 in the WRMM model – Figures E-1).

After the project infrastructure components and WRMM were finalized for each of the development scenarios, the "actual" weekly required diversion from the River was developed. This was accomplished by subtracting the unused flow (Diversion Channel 10) from the constant diversion rate. The "actual" weekly diversion requirements for the three development scenarios were re-entered into the SSRB model. The water availability files obtained from these final SSRB runs were in-turn re-entered into the project WRMM to produce the final model results, complete with project deficits.

3.0 Project WRMM Simulations

This section outlines the main criteria and assumptions used for the three development scenarios for this study.

3.1 Model Layout and Simulation Period

The system layout used in the modelling for each development scenario is illustrated on the WRMM schematics, Figures E-1; E-2 & E-3. The model input tables for each development scenario are located at the back of this appendix.

The simulation period for the modelling was from 1928 to 1995. It was assumed that diversion from the Red Deer River began in week 16 (April 16) and ended in week 43 (October 28), of each year.

Irrigation demand started at week 17 (April 30) and ended at week 40 (October 7).

3.2 Main Supply System

As shown on the schematics (Figure E-1 to E-3), water is diverted from the Red Deer River (node 1), to Reservoir A1 (node 3). The delivery channel (13) in the model is a pipeline and therefore no losses are accounted for evaporation or seepage.

3.3 Reservoirs

3.3.1 General

Three reservoir nodes were incorporated into the model for all of the development scenarios:

i) Reservoir A1 (node 3);
ii) Coulee storage in the tributary upstream of Reservoir A1 – Upstream Reservoir (node 2);
iii) Acadia Recreational Reservoir (node 5).

Specific modelling criteria for the individual reservoirs are provided in the following sections. However; a number of criteria were common to all reservoirs as per the following:

1) In order to store the winter precipitation and local spring runoff in the reservoirs (and take advantage of the water for irrigation), the winter water level in the reservoirs was maintained at 0.3m below full supply level (FSL). This also minimizes spill out of the reservoir outside of the irrigation season.

2) Net evaporation (evaporation minus precipitation), was accounted for in the model. Precipitation data for the Climatic Station at Empress was obtained from the AENV SSRB weekly natural flow database. Gross shallow lake evaporation data at Brooks was obtained from AENV's Surface Water Assessment Branch. From AENV's iso-evaporation lines, Acadia Valley has a mean annual evaporation of 733 mm versus

the Brooks station at 739 mm. Therefore, the Brooks evaporation files were adjusted by a factor of 0.992 (733/739), for the model.

3) Rating curves were entered for the reservoir outlet structures as well as stage storage information for each reservoir. Full supply levels and operating rules were established for each reservoir, for each development scenario and incorporated into the model. (Refer to Figure E-4 and E-5 for stage-storage curves; FSL and operating levels).

3.3.2 Reservoir A1 & Upstream Reservoir

The West Dam of Reservoir A1 (node 3) creates an upstream reservoir in the tributary coulee that the dam is situated on. This upstream reservoir will not be intentionally flooded or used for irrigation storage because of its proximity to the Red Deer River valley slopes (refer to Section 7.3 in the main report for more information). However, natural runoff flows would be captured in this location. Therefore this upstream reservoir was added into the model as node 2.

Runoff into the upstream reservoir was only considered in the spring (refer to Appendix D Hydrology). Naturalized spring runoff flows into the coulee (NATWTRIB) were entered into node 2 and any upstream licensed allocations (LICWTRIB) were taken out. This in-effect simulates the actual runoff that reaches the reservoir (natural flows less upstream consumptive use). Natural spring runoff tables that were entered into the model were presented in Appendix D.

It was determined that the amount of storage upstream of the West Dam is sufficient to store the runoff in the coulee in any individual year for the simulated natural flows from 1925 to 1995. Therefore, in order to take advantage of this stored water for irrigation and to minimize the period of time water stays in the coulee upstream of the West Dam, the model assumed that stored water in the upstream reservoir was pumped into Reservoir A1. Pumping begins at the start of irrigation demand (April 30) at a maximum diversion rate of 0.5 m^3/s, which results in the upstream reservoir being emptied (dry) by early to mid May.

Seepage out of Reservoir A1 was accounted for in the model. The seepage rate was arbitrarily established at a constant rate of 0.008 m^3/s, which equates to approximately 0.3 vertical metres of reservoir drop (or 250 dam^3/year).

It was determined in Section 7.3 of the main report, that Reservoir A1 does not require a service spillway, because most runoff does not reach the reservoir until it is pumped from the upstream reservoir; and the irrigation outlet structures will be adequate to accommodate any spill from the reservoir during a flood.

The Secondary A irrigation outlet structure invert had to be set at elevation 715m and the Secondary B structure invert at 712 m; in order to provide gravity flow to their respective downstream system. As a result, the "full" irrigation design flow for each canal system can only be delivered above the reservoir low operating level (LOL) of 717m. However, a reduced flow rate can still be delivered below this elevation. For modelling purposes it was assumed that the reservoir minimum operating level (MOL) is 715m. The outlet structure rating curves for each structure were entered into the model to simulate the reduced outlet capacity below elevation 717m.

The proposed FSL and storage capacities for Reservoir A1 are provided in Table E1 and the stage-storage curve in Figure D-4.

Table E1
Reservoir A1 Operating Characteristics

Scenario	FSL (m)	LOL (m)	MOL (m)	Live Storage (above MOL) (dam^3)	Dead Storage (below MOL) (dam^3)
1	723	717	715	7,951	5,500
2	726	717	715	12,300	5,500
3	728.5	717	715	17,038	5,500

3.3.3 Acadia Recreational Reservoir

This is an existing recreational reservoir and will not provide storage for the proposed irrigation system. This reservoir is used as a tail-out for Secondary A canal and will act as an operational sump for a pressurized pump system to irrigation Block 4 (Scenario 2) and Block 3 & 4 (Scenario 3). It is anticipated that the actual water level in this reservoir will fluctuate a bit during varying periods of irrigation demand (0.3 to 0.5m), however for WRMM modelling, it was assumed that the reservoir water level maintained a constant level at 0.3 – 0.5m below FSL, depending on the scenario. This would minimize spills into Kennedy Coulee due to irrigation demand fluctuations for Blocks 3 and 4.

Runoff into the upstream reservoir was only considered in the spring as per Reservoir A1. Naturalized spring runoff flows (NATKENCK) were entered into node 5 and any upstream licensed allocations (LICKENCK) were taken out. This in-effect simulates the actual runoff that flows into the reservoir (natural flows less upstream consumptive use).

The majority of spring runoff flows into this reservoir spill downstream into Kennedy Coulee. In addition to runoff spills, a constant base flow in the canal system is normally incorporated in AAFRD's application of the IDM. For this project, it was set at 0.05 m^3/s. Therefore, as this base flow (as well as any additional spill volumes) return to the river, it may be available for downstream livestock and domestic use.

3.4 Main Delivery System

Figures E-1 to E-3 show that there are two main delivery systems out of Reservoir A1; Secondary A Canal and Secondary B Pipeline. Secondary A is a gravity canal that feeds Block 1A, as well as delivers the demand requirements for Blocks 3 & 4 to the Acadia Recreational Reservoir. Evaporation and seepage considerations for this canal were incorporated into the IDM irrigation demand files developed by AAFRD. No return flow has been allowed for this canal at Acadia Reservoir because of the irrigation demand to Blocks 3 and 4.

Secondary A Canal branches off and gravity feeds Block 2 via a siphon through Kennedy Coulee for Scenarios 2 and 3. Return flows via a tailout to a tributary to Kennedy Coulee was incorporated into the model, near the end of the canal. Return flows were developed by the AAFRD IDM and determined that the return flows would be relatively insignificant (average annual flows of 0.11 to 0.13 m^3/s).

Secondary B is a closed pipeline system that feeds Block 1B.

The AAFRD IDM assumed that irrigation Blocks 1A, 1B and 2 would be gravity fed via pipeline laterals to each quarter section and then the farmer would pump to his pivot. The two irrigation blocks that are fed out of the Acadia Recreational Reservoir (Blocks 3 & 4) were assumed to have pipeline laterals run directly to irrigate through each pivot and would be fed via pump systems with adequate pressure to irrigate through each the pivot (i.e on-farm pumping is not required).

4.0 Simulation Results

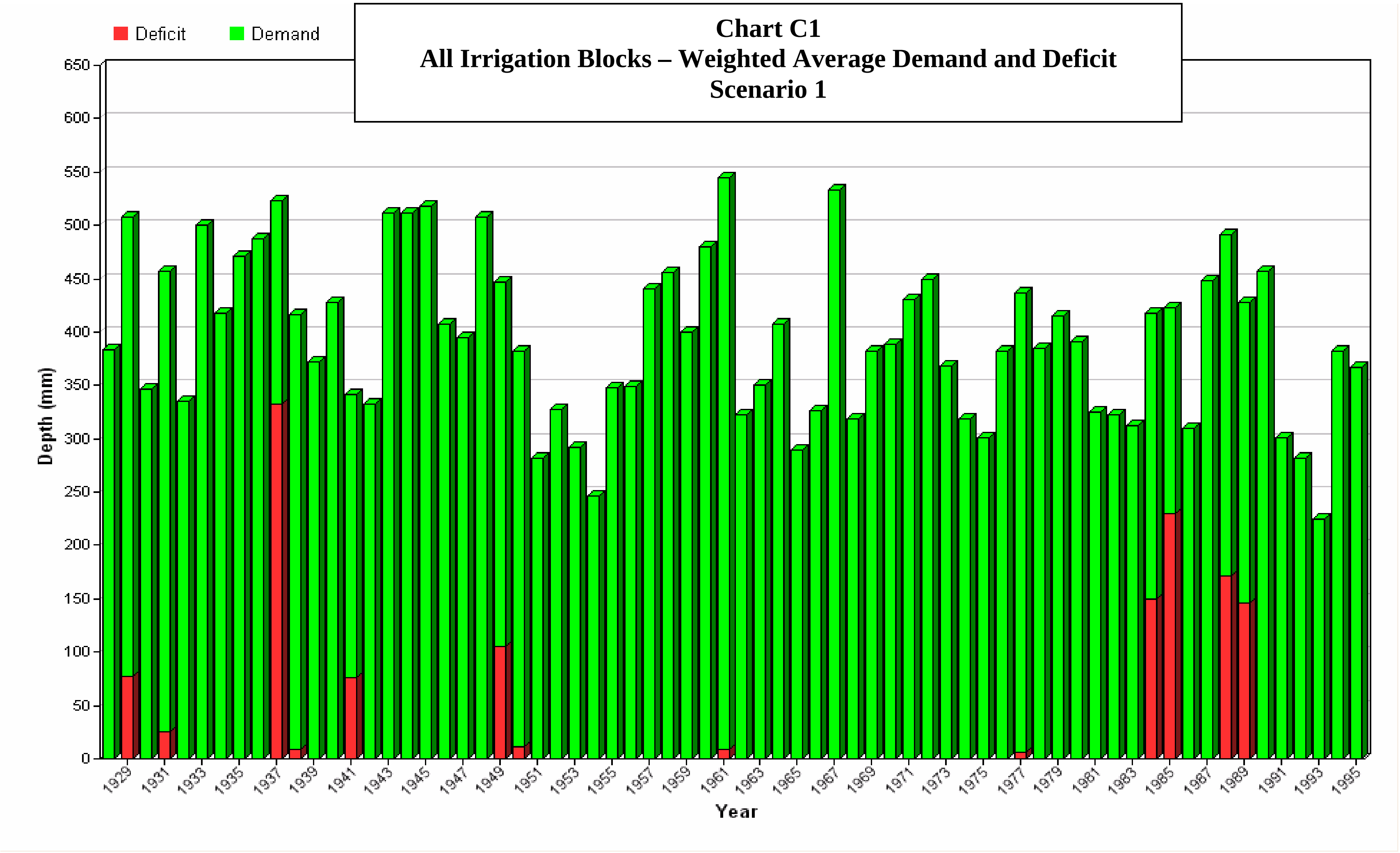
4.1 Irrigation

Charts C1, C2 & C3 show the weighted average annual demand and deficits (mm) for the entire project irrigation area for the three development scenarios. The annual demands and deficits are aggregated (weighted) by the area of each irrigation block. Performance of the individual blocks was very similar to the project aggregate.

The demand shown on the charts reflect the GDD determined by the IDM. Deficits reflect the GDD that could not be accommodated annually, over the modelling period. Deficits take into account the GDD, runoff, available flow in the Red Deer River, reservoir losses and the available storage in the reservoir carried over from the previous year.

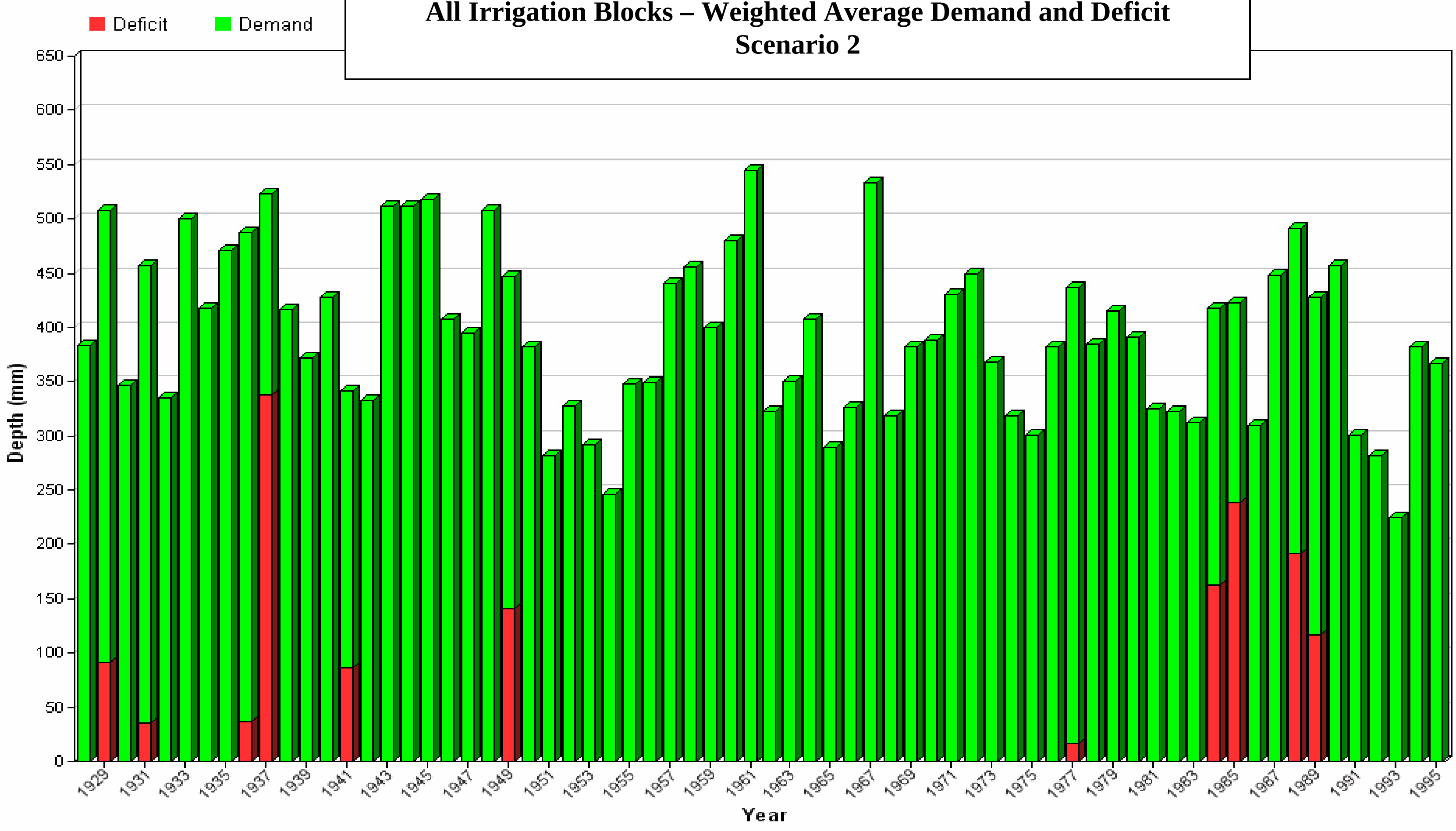
Charts C1 to C3 show that the acceptable deficit criterion was met for all three development scenarios; an annual irrigation demand deficit of 100mm or greater only occurred 6 out of 68 model years (8.8%). The charts also show that the total number of deficit years (any amount of annual deficit) were fairly consistent for all the scenarios, with Scenario 2 being the least at 11 years and Scenario 3 being the most at 14 years.

The distribution of irrigation demand varies for each block, year by year. An example of a dry year irrigation demand distribution for two of the blocks on Scenario 1 is shown on Charts C4 and C5.



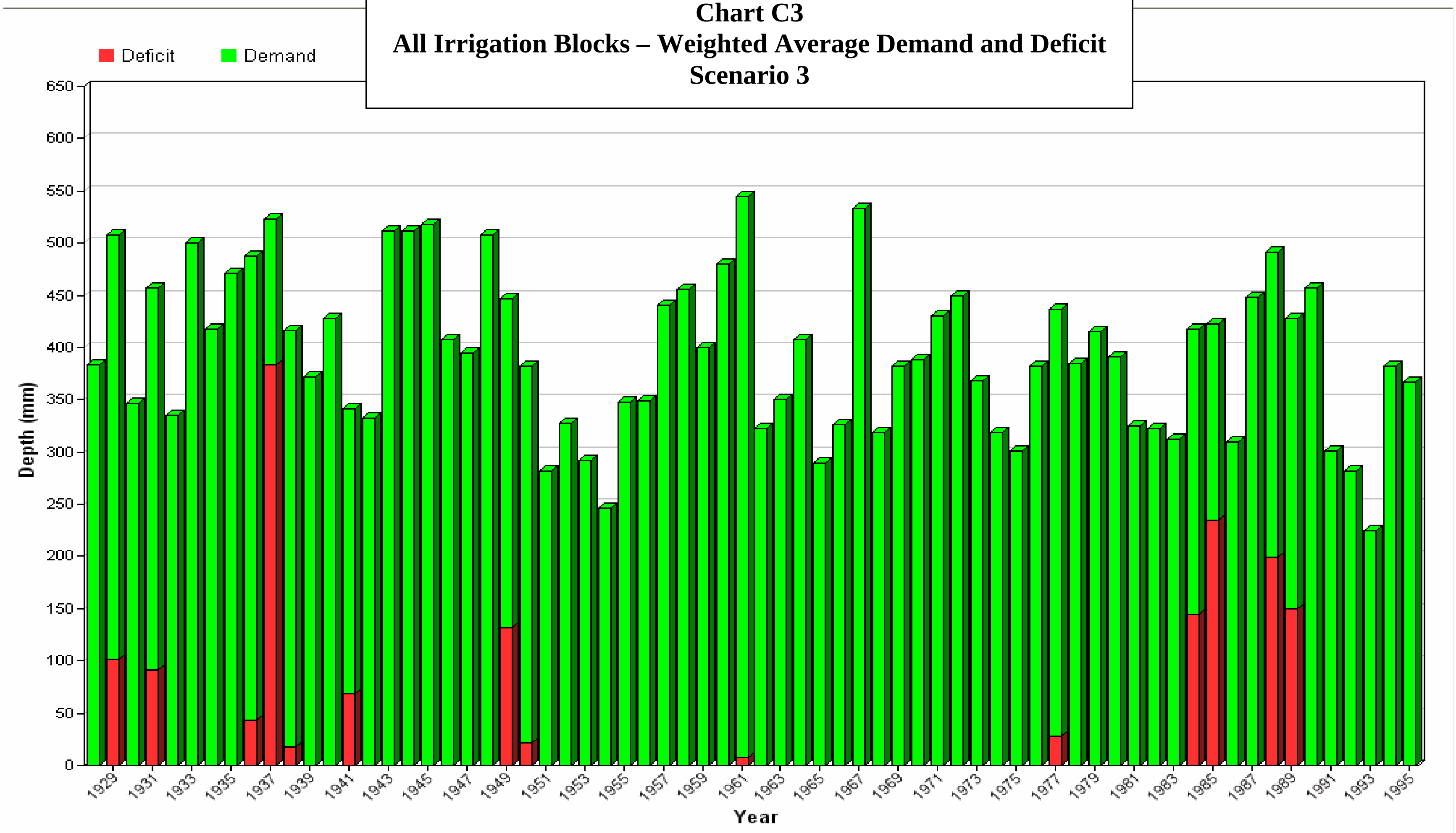
Max. Diversion Rate = 2 m^3/s, Reservoir FSL = 723 m, Live Storage = 7951 dam^3, Total Irrigation Blocks Area = 5464 ha

Chart C2
All Irrigation Blocks – Weighted Average Demand and Deficit
Scenario 2



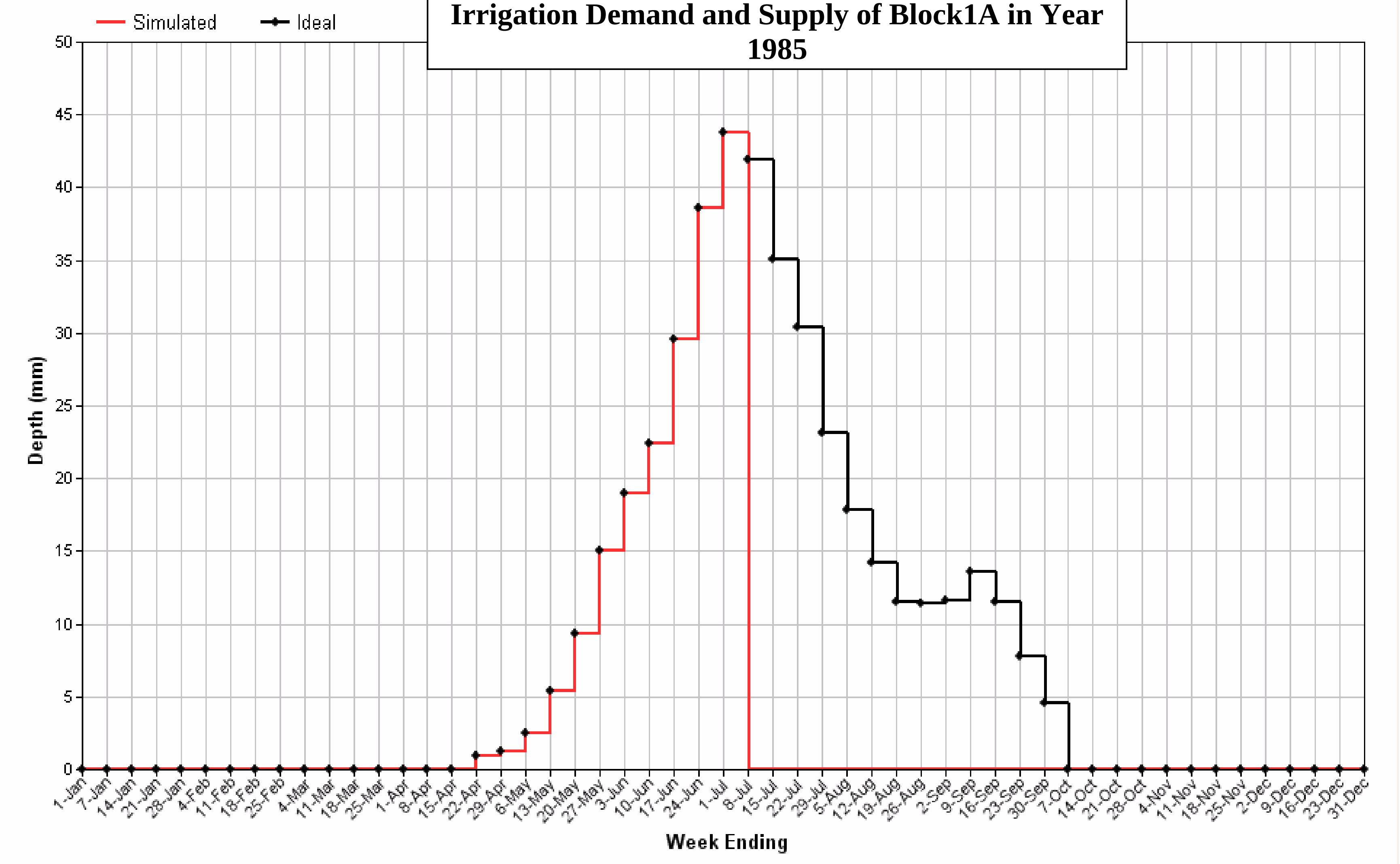
Max. Diversion Rate = 4 m^3/s, Reservoir FSL = 726 m, Live Storage = 12,300 dam^3, Total Irrigation Blocks Area = 8,904ha

Chart C3
All Irrigation Blocks – Weighted Average Demand and Deficit
Scenario 3



Max. Diversion Flow Rate = 4 m^3/s, Reservoir FSL = 728.5m, Live Storage = 17,038 dam^3, Total Irrigation Blocks Area = 10,927 ha

Chart C4 – Scenario 1
Irrigation Demand and Supply of Block1A in Year 1985



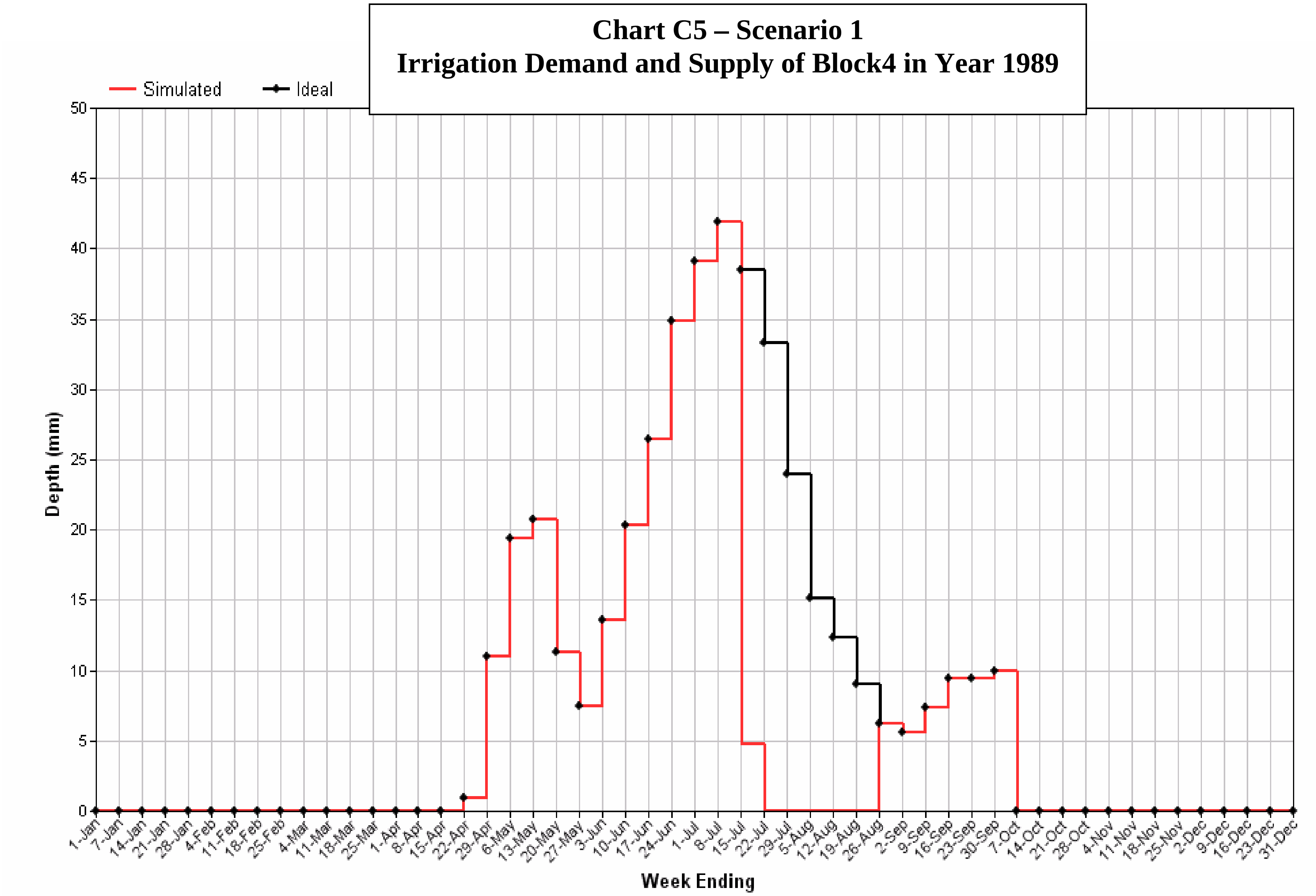


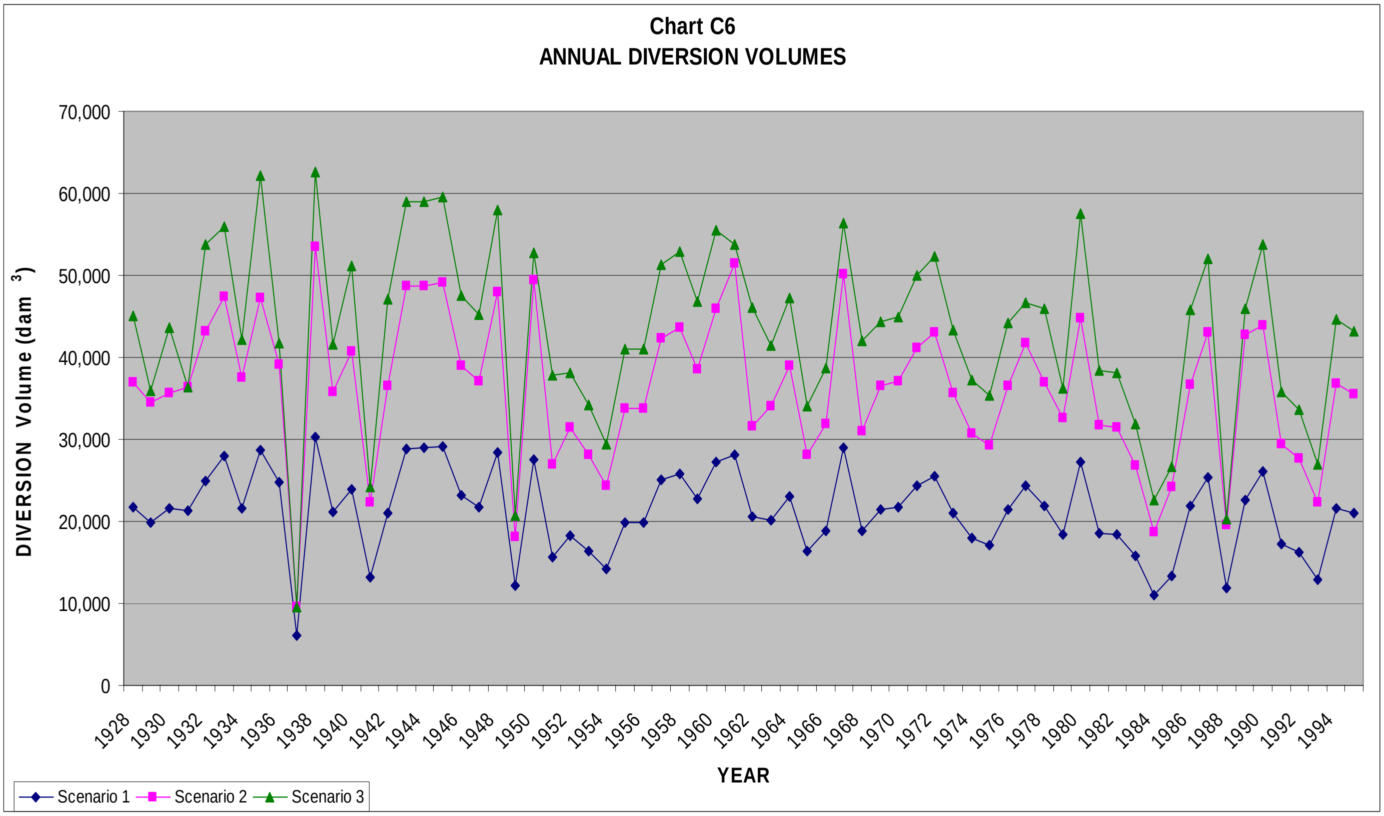
Chart C5 – Scenario 1
Irrigation Demand and Supply of Block4 in Year 1989
Simulated
Ideal
Depth (mm)
Week Ending
0
5
10
15
20
25
30
35
40
45
50
1-Jan
7-Jan
14-Jan
21-Jan
28-Jan
4-Feb
11-Feb
18-Feb
25-Feb
4-Mar
11-Mar
18-Mar
25-Mar
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
11-Nov
18-Nov
25-Nov
2-Dec
9-Dec
16-Dec
23-Dec
31-Dec

4.2 Diversion Volumes

Chart C6 and Table E2 illustrate the annual diversion volume over the model period for the three development scenarios.

Table E2
Annual Diverted Volumes from the River

Year	Annual Diverted Volume from Red Deer River (dam^3)		
	Scenario 1	Scenario 2	Scenario 3
Mean	21,237	36,132	43,235
Max	30,250	53,424	62,586
Min	6,073	9,518	9,518



4.3 Channel Flows

The maximum channel flows from the WRMM are summarized in Table E3.

Table E3
Maximum Flow Rate in Canals and Pipelines

Schematic ID #	Description	Maximum Flow Rate (m^3/s)		
		Scenario 1	Scenario 2	Scenario 3
31	Secondary A d/s of Reservoir A1	1.00	1.00	1.00
34	Secondary B d/s of Reservoir A1	3.25	6.10	7.68
30		2.46	2.46	2.46
45		0.79	0.79	0.79
32	Pipeline to Block 4	0.79	0.79	0.79
47	Secondary A - Syphon to Block 2		2.85	2.85
54	Secondary C Pipeline to Block 3			1.58
33			2.68	2.68
72	Secondary A Canal - Return Flow		0.17	0.17

4.4 Reservoir Water Levels

Water levels in Reservoir A1 very significantly throughout the year, but rarely drop below MOL (715 m). A sample of Reservoir A1 water levels for Scenario 1 are shown in Charts C7, C8 & C9.

Chart C7 – Scenario 1
Water Level in Reservoir "A1" from 1930 to 1939

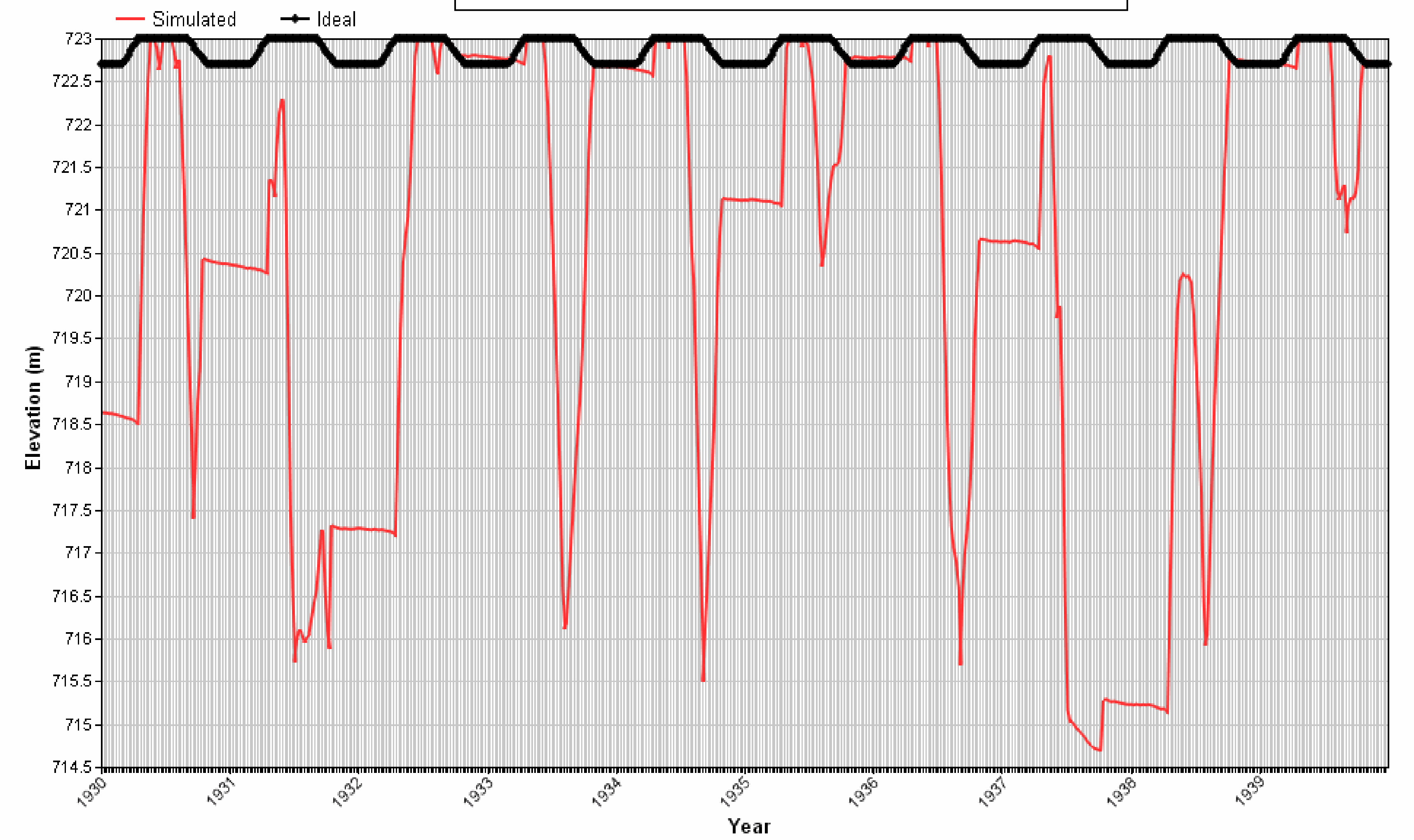


Chart C8 – Scenario 1
Water Level in Reservoir "A1" from 1950 to 1959

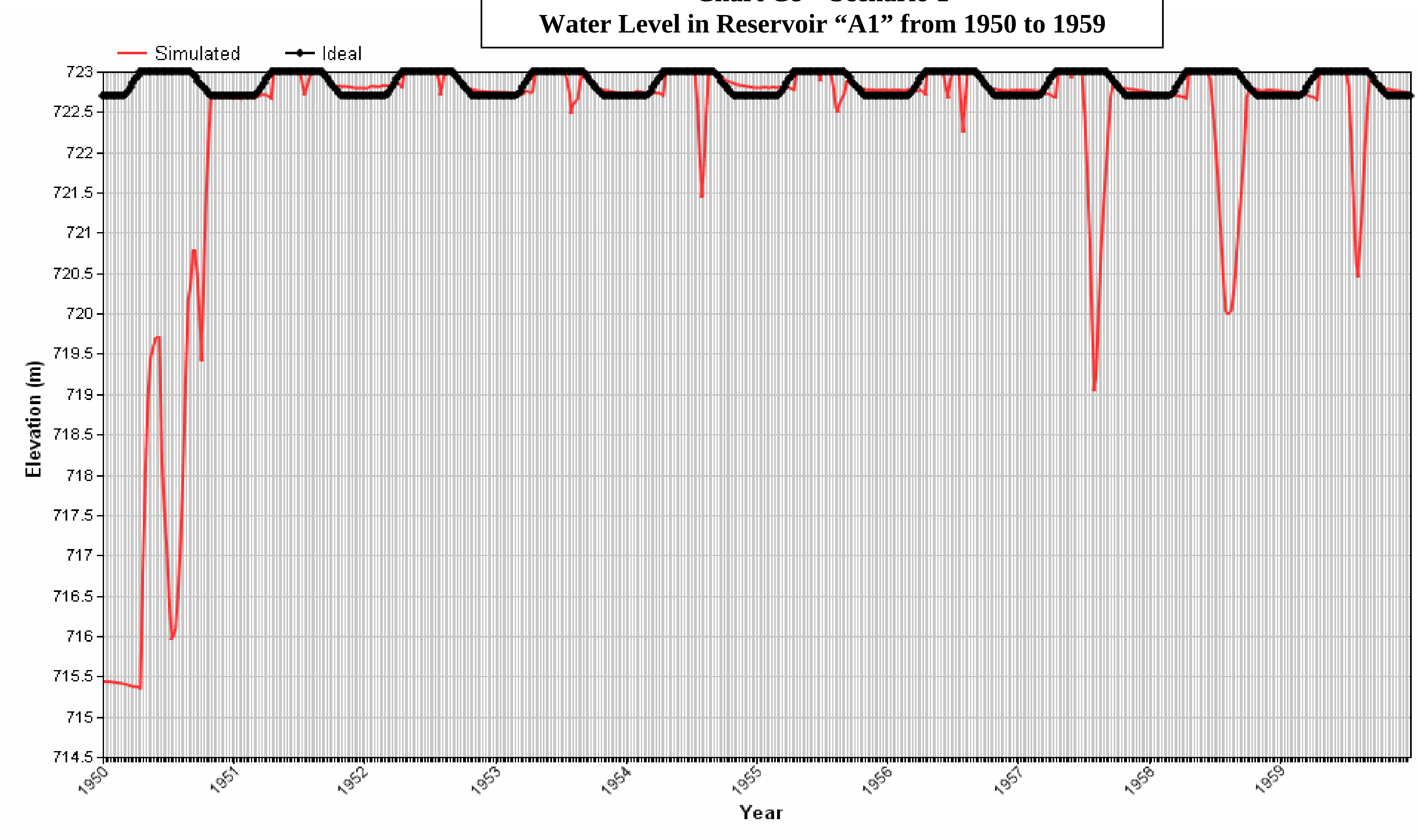


Chart C9 – Scenario 1
Water Level in Reservoir "A1" from 1980 to 1989

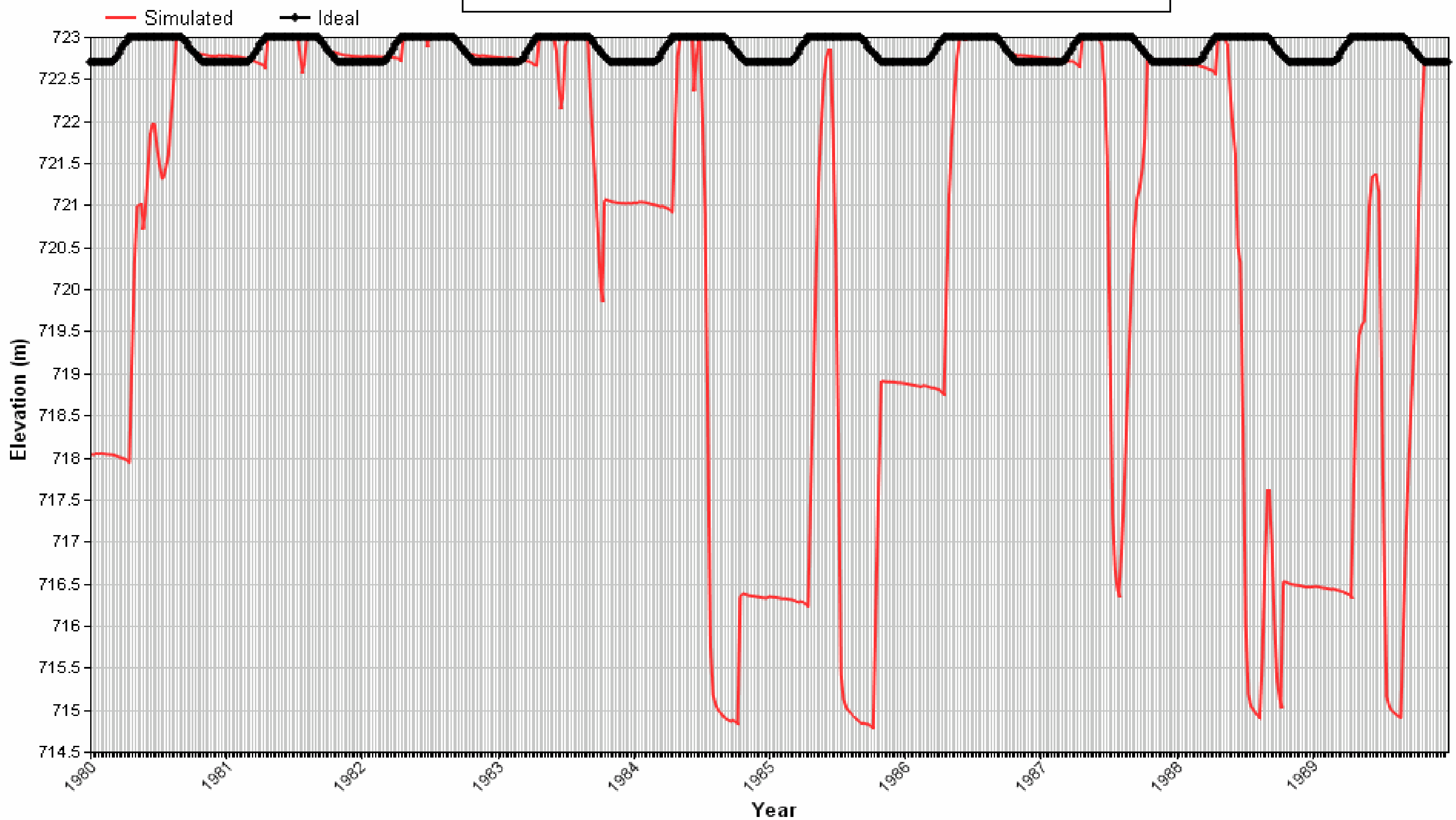


Figure E-1
ACADIA VALLEY IRRIGATION PROJECT - WRMM SCHEMATIC
Scenario 1

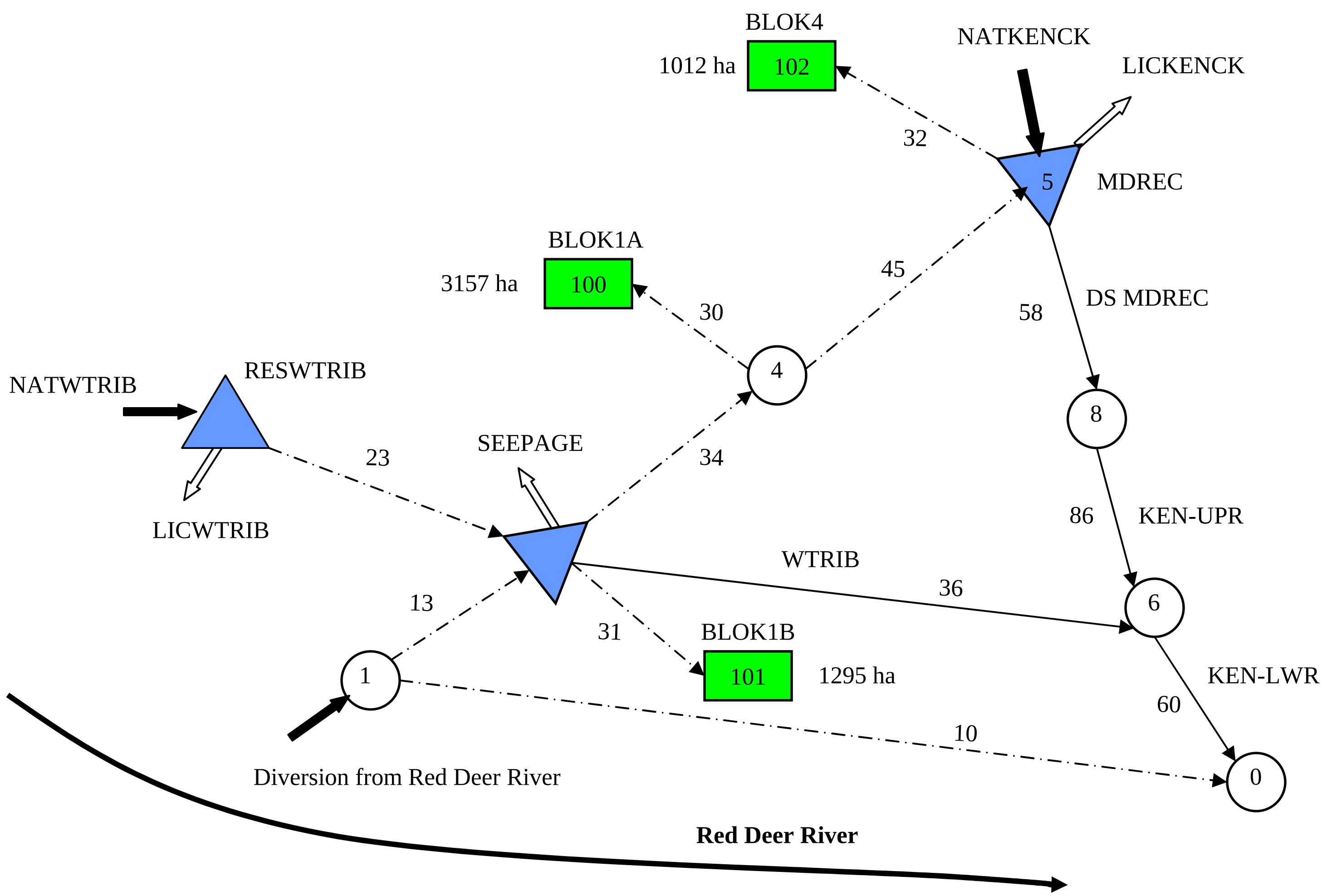


Figure E-2
ACADIA VALLEY IRRIGATION PROJECT - WRMM SCHEMATIC
Scenario 2

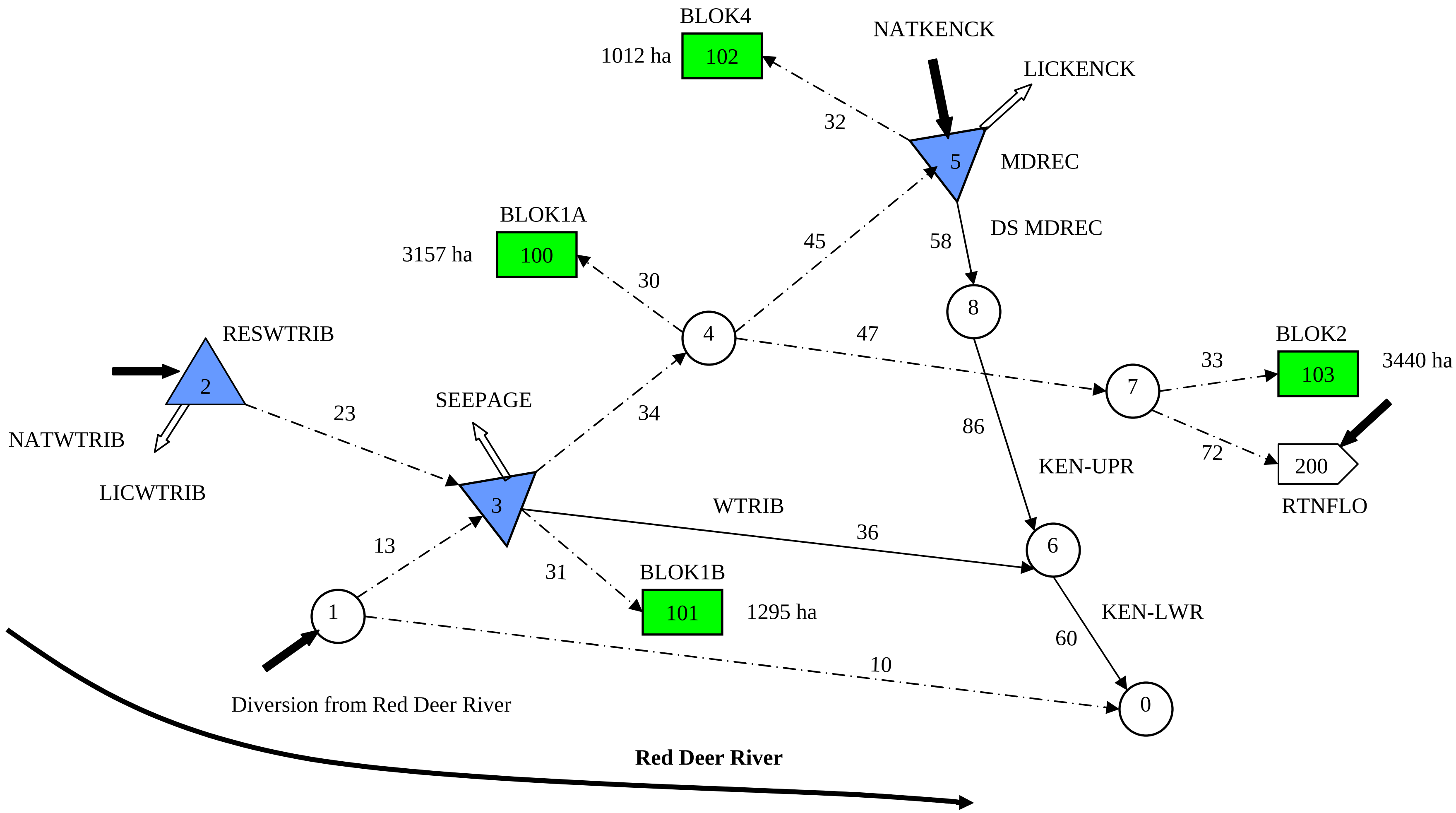
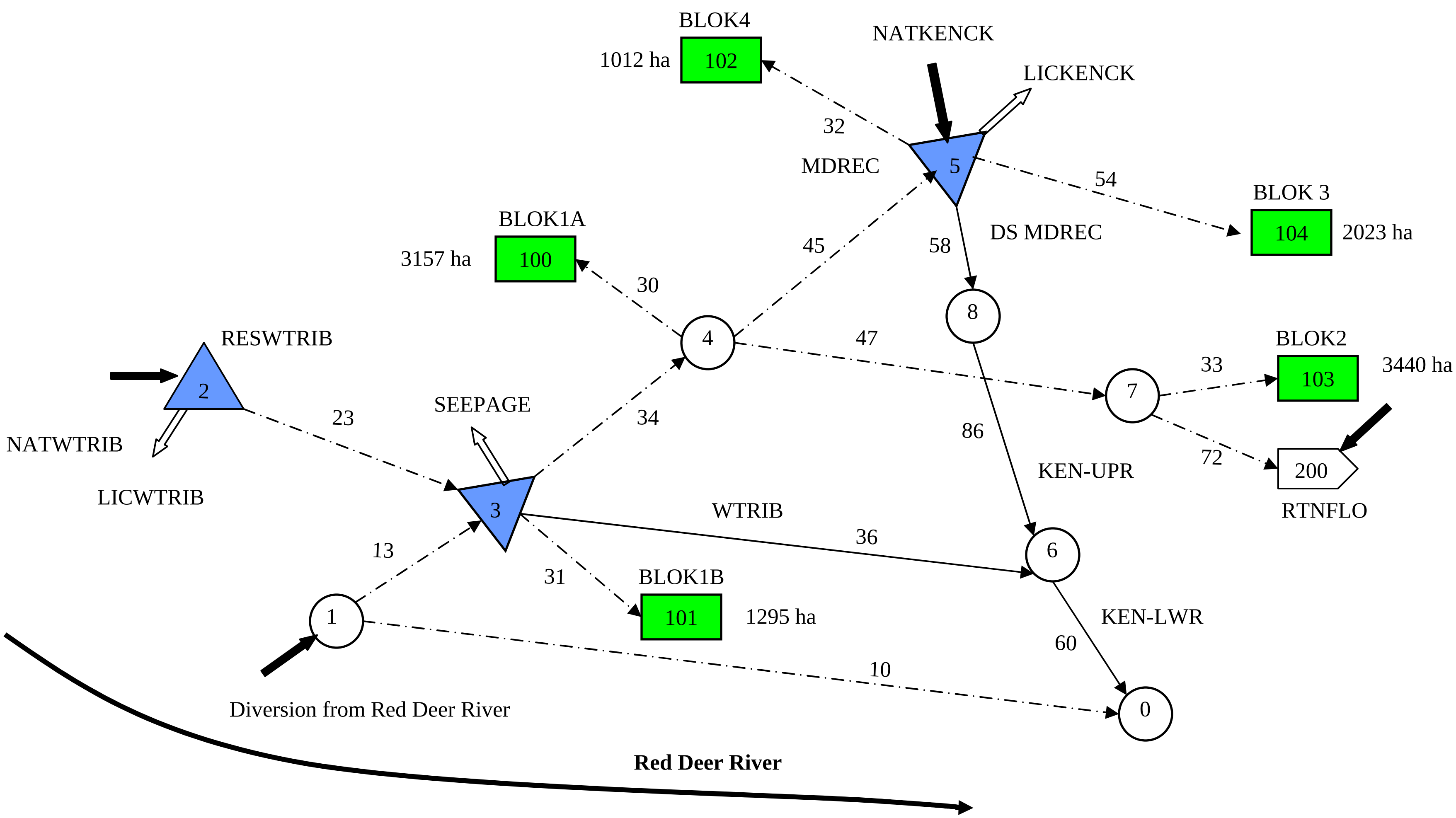
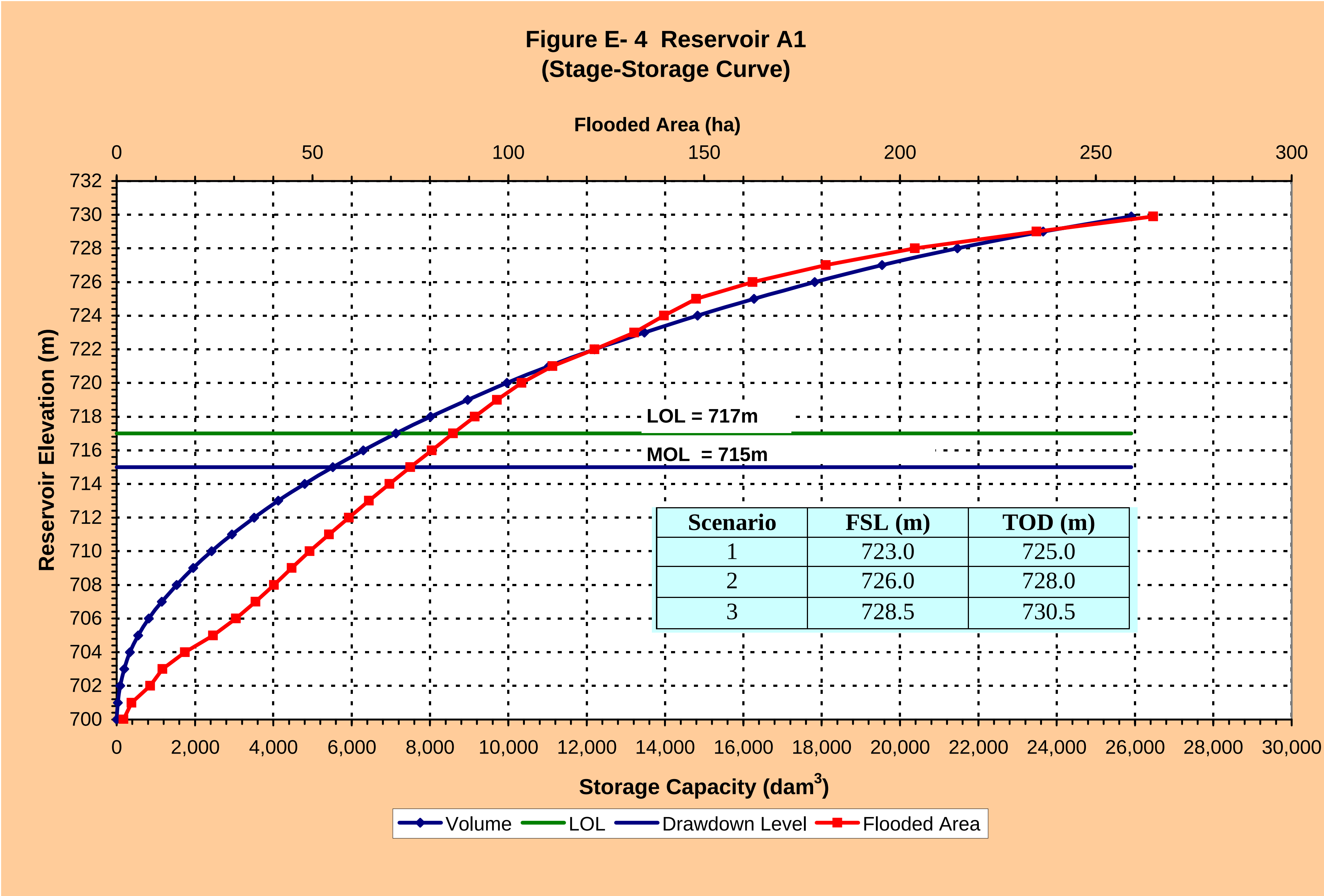


Figure E-3
ACADIA VALLEY IRRIGATION PROJECT - WRMM SCHEMATIC
Development Scenario 3





Scenario	FSL (m)	TOD (m)
1	723.0	725.0
2	726.0	728.0
3	728.5	730.5

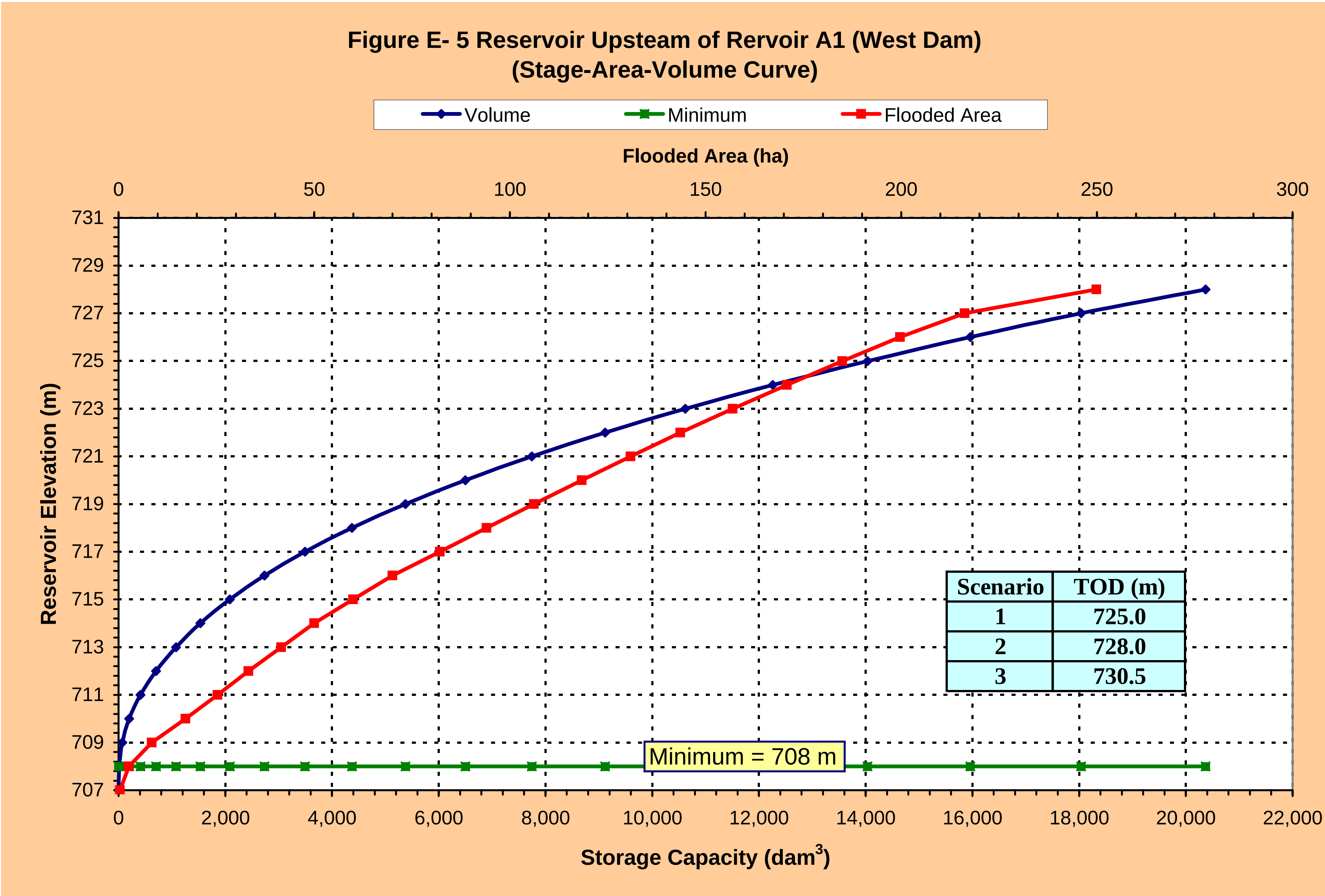


Figure E- 5 Reservoir Upsteam of Rervoir A1 (West Dam)
(Stage-Area-Volume Curve)
Volume
Minimum
Flooded Area
Flooded Area (ha)
0
50
100
150
200
250
300
Reservoir Elevation (m)
731
729
727
725
723
721
719
717
715
713
711
709
707
Scenario
TOD (m)
1
725.0
2
728.0
3
730.5
Minimum = 708 m
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
Storage Capacity (dam3)

WRMM Input Files

Scenario 1

```
$IDENT
REFNAM  SCENARIO 1
STUDY
MINIMUM ACREAGE
SYSTEM
WRMM
RUN
DRIVEN BY 2 M3/S SUPPLY
USER    NAVA POKHAREL
DATE    DECEMBER 7, 2004
REMARKS DIVERSION NEED DETERMINATION
TITLE   TO OPTIMIZE DIVERSION AND STORAGE
$SIMCON
INTRVLS      52   52    1
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    8
CYCLES       68
START       001 1928
OUTNODES      6
    2    3    5  100  101  102
OUTLINKS     12
   13   23   34   36   45   58   86   60   30   31   32   10
OUTEVAP
DBOUT    S
$PHYSYS
RESERV        2  RESWTRIB                 10    2
       0.0     707.0      70.0     709.0     703.0     712.0    2084.0     715.0
    3495.0     717.0    6499.0     720.0    9117.0     722.0   12258.0     724.0
   18039.0     727.0   20369.0     728.0
  800  0.0  801  0.0
RESERV        3  RES-A                    10    2
       0.0     700.0     822.0     706.0    1954.0     709.0    5522.0     715.0
    7131.0     717.0   11035.0     721.0   14832.0     724.0   17822.0     726.0
   21463.0     728.0   25905.0     730.0
  800 .992  801  1.0
RESERV        5  RES-MDREC                 4    2
       0.0    695.80     31.45    697.63    132.70    699.45    265.80    700.68
  800 .992  801  1.0
IRRIGAT     100  BLOK1A                    0                        3157.        1.
IRRIGAT     101  BLOK1B                    0                        1295.        1.
IRRIGAT     102  BLOK4                     0                        1012.        1.
NATCHL       36  WTRIB                     3    6
NATCHL       58  DSMDREC                   5    8
NATCHL       86  KEN-UPR                   8    6
NATCHL       60  KEN-LWR                   6    0
DIVCHL       10  SUPPLYSPILL               1    0                   10.00
DIVCHL       13  RDSUPPLY                  1    3                    2.00
DIVCHL       23  NATWTRIB                  2    3                    0.50
DIVCHL       31  TOBLK1B                   3  101                    5.00
DIVCHL       34  TOJUNC4                   3    4                   10.00
DIVCHL       30  TOBLOK1A                  4  100                   10.00
DIVCHL       45  TORESMDREC                4    5                   10.00
DIVCHL       32  TOBLOK4                   5  102                   10.00
JUNCTION      4  BLOK1ATO
JUNCTION      8
JUNCTION      6  WTRIBMOUTH
CTLSTR           BLOK1B                   31    3    9   CC
       0.0    715.00       0.2    715.41       0.6    715.80       1.0    716.49
       1.2    716.96       1.8    718.79       2.4    721.32       3.0    723.00
       4.0    728.00
CTLSTR           BLOK1A&4                 34    3    9   CC
```

```
       0.0    715.00       0.4    715.50       1.4    716.00       2.2    716.32
       3.0    716.69       4.0    717.00       5.0    718.25       6.0    719.24
       7.0    730.00
$PENSYS
RESERV   1    RESERVOIR          1    1    1
       2.0
     300.0
    2  RESERVOIR   1
    0      728.      707.
RESERV   2    RESERVOIR          1    1    2
       3.0
      10.0     200.0
    3  RESERVOIR   5
    0      723.     722.7      715.
   61      723.     722.7      715.
  105      723.     723.0      715.
  244      723.     723.0      715.
  301      723.     722.7      715.
RESERV   3    RESERVOIR          1    1    1
     500.0
     300.0
    5  RESERVOIR   1
    0    700.68    699.45
IRRIGAT  1    IRRIG              3    1
       20.
  100  BLOK1A      1
    1      1.00
  101  BLOK1B      1
    1      1.00
  102  BLOK4       1
    1      1.00
NATCHL   1    RIPARIAN           4    1    0
       5.0
   36  WTRIB       1
    1       50.       0.
   58  DS MDREC    1
    1       50.       0.
   86  KEM-UPR     1
    1       50.       0.
   60  KEM-LWR     1
    1       50.       0.
DIVCHL   1    CANALS             5
   10  SLYSPILL    1
    1      10.0
   13  RDSUPPLY    1
    1       2.0
   23  NATWTRIB    3
    1       0.0
  121       0.5
  152       0.0
   34  TOJUNC4     3
    1       0.0
  106      10.0
  301       0.0
   45  TOMDREC     3
    1       0.0
  106      10.0
  301       0.0
DIVCHL   2    IRRGAT             3
   30  TOBLOK1A    1
    1      10.0
   31  TOBLOK1B    1
    1      10.0
```

```
   32  TOBLOK4     1
    1      10.0
$WATDEM
MINOR         3
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008
MINOR         2 LICWTRIB
MINOR         5 LICKENCK
IRRIGAT     100 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     101 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     102 *BLOK328       C C C
       1.0
       0.0
       1.0
$WATSUP
INSTOR        2                                         707.00
INSTOR        3                                         722.70
INSTOR        5                                         699.45
INFLNOD       1 DIVCH 13          0
INFLNOD       2 NATWTRIB          0
INFLNOD       5 NATKENCK          0
EVAP        800 EVP ACAD
PRPT        801 PG  ACAD
$LAGDAT
$ENDFILE
```

Scenario 2

```
$IDENT
REFNAM  SCENARIO 2
STUDY
MINIMUM ACREAGE
SYSTEM
WRMM
RUN
DRIVEN BY 4 M3/S SUPPLY
USER    NAVA POKHAREL
DATE    DECEMBER 7, 2004
REMARKS DIVERSION NEED DETERMINATION
TITLE   TO OPTIMIZE DIVERSION AND STORAGE
$SIMCON
INTRVLS       52   52    1
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    8
CYCLES        68
START        001 1928
OUTNODES       8
    2    3    5  100  101  102  103  200
OUTLINKS      15
   13   23   34   36   45   58   86   60   30   31   32   10   47   33   72
OUTEVAP
DBOUT    S
$PHYSYS
RESERV         2  RESWTRIB                  10    2
      0.0     707.0      70.0     709.0     703.0     712.0    2084.0     715.0
   3495.0     717.0    6499.0     720.0    9117.0     722.0   12258.0     724.0
  18039.0     727.0   20369.0     728.0
  800  0.0   801  0.0
RESERV         3  RES-A                     10    2
      0.0     700.0     822.0     706.0    1954.0     709.0    5522.0     715.0
   7131.0     717.0   11035.0     721.0   14832.0     724.0   17822.0     726.0
  21463.0     728.0   25905.0     730.0
  800 .992   801  1.0
RESERV         5  RES-MDREC                  4    2
      0.0    695.80     31.45    697.63    132.70    699.45    265.80    700.68
  800 .992   801  1.0
IRRIGAT      100  BLOK1A                     0                   3157.        1.
IRRIGAT      101  BLOK1B                     0                   1295.        1.
IRRIGAT      102  BLOK4                      0                   1012.        1.
IRRIGAT      103  BLOK2                      0                   3440.        1.
WITHDR       200  RTFLO
NATCHL        36  WTRIB                      3    6
NATCHL        58  DSMDREC                    5    8
NATCHL        86  KEN-UPR                    8    6
NATCHL        60  KEN-LWR                    6    0
DIVCHL        10  SUPPLYSPILL                1    0              10.00
DIVCHL        13  RDSUPPLY                   1    3               4.00
DIVCHL        23  NATWTRIB                   2    3               0.50
DIVCHL        31  TOBLK1B                    3  101              10.00
DIVCHL        34  TOJUNC4                    3    4              10.00
DIVCHL        30  TOBLOK1A                   4  100              10.00
DIVCHL        45  TORESMDREC                 4    5              10.00
DIVCHL        32  TOBLOK4                    5  102              10.00
DIVCHL        47  TOJUNC7                    4    7              10.00
DIVCHL        33  TOBLOK2                    7  103              10.00
DIVCHL        72  TORETFLO                   7  200              10.00
JUNCTION       4  BLOK1ATO
JUNCTION       8
JUNCTION       6  WTRIBMOUTH
```

```
JUNCTION      7  BLOK2JUNC
CTLSTR           BLOK1B                   31    3    9   CC
       0.0    715.00       0.2    715.41       0.6    715.80       1.0    716.49
       1.2    716.96       1.8    718.79       2.4    721.32       3.0    723.00
       4.0    728.00
CTLSTR           BLOK1A4&2                34    3    9   CC
       0.0    715.00       0.6    715.56       2.0    716.00       3.4    716.33
       5.2    716.70       6.0    717.00       7.0    718.25       8.0    728.00
       9.0    730.00
$PENSYS
RESERV   1    RESERVOIR           1    1    1
       2.0
     300.0
    2  RESERVOIR   1
    0      728.      707.
RESERV   2    RESERVOIR           1    1    2
       3.0
      10.0     200.0
    3  RESERVOIR   5
    0      726.     725.7      715.
   61      726.     725.7      715.
  105      726.     726.0      715.
  244      726.     726.0      715.
  301      726.     725.7      715.
RESERV   3    RESERVOIR           1    1    1
     500.0
     300.0
    5  RESERVOIR   1
    0    700.68    699.45
IRRIGAT  1    IRRIG               4    1
       20.
  100  BLOK1A      1
    1      1.00
  101  BLOK1B      1
    1      1.00
  102  BLOK4       1
    1      1.00
  103  BLOK2       1
    1      1.00
WITHDR   1    RETFLO              1    1
  200
       0.0
      21.0
NATCHL   1    RIPARIAN            4    1    0
       5.0
   36  WTRIB       1
    1       50.       0.
   58  DS MDREC    1
    1       50.       0.
   86  KEM-UPR     1
    1       50.       0.
   60  KEM-LWR     1
    1       50.       0.
DIVCHL   1    CANALS              6
   10  SLYSPILL    1
    1      10.0
   13  RDSUPPLY    1
    1       4.0
   23  NATWTRIB    3
    1       0.0
  121       0.5
  152       0.0
   34  TOJUNC4     3
```

```
    1       0.0
  106      10.0
  301       0.0
   45  TOMDREC     3
    1       0.0
  106      10.0
  301       0.0
   47  TOMDREC     3
    1       0.0
  106      10.0
  301       0.0
DIVCHL   2    IRRGAT              4
   30  TOBLOK1A    1
    1      10.0
   31  TOBLOK1B    1
    1      10.0
   32  TOBLOK4     1
    1      10.0
   33  TOBLOK4     1
    1      10.0
DIVCHL   3    RETFLO              1
   72  TORETFLO    1
    1      10.0
$WATDEM
MINOR         3
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008
MINOR         2 LICWTRIB
MINOR         5 LICKENCK
IRRIGAT     100 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     101 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     102 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     103 *BLOK328       C C C
       1.0
       0.0
       1.0
MAJOR       200 *RET328
$WATSUP
INSTOR        2                                             707.00
INSTOR        3                                             725.70
INSTOR        5                                             699.45
INFLNOD       1 RDINFLO4          0
INFLNOD       2 NATWTRIB          0
INFLNOD       5 NATKENCK          0
INFLNOD     200 INFL328           0
EVAP        800 EVP ACAD
PRPT        801 PG  ACAD
$LAGDAT
$ENDFILE
```

Scenario 3

```
$IDENT
REFNAM  SCENARIO 3
STUDY
MINIMUM ACREAGE
SYSTEM
WRMM
RUN
DRIVEN BY 4 M3/S SUPPLY
USER    NAVA POKHAREL
DATE    MARCH 01, 2004
REMARKS DIVERSION NEED DETERMINATION
TITLE   TO OPTIMIZE DIVERSION AND STORAGE
$SIMCON
INTRVLS       52   52    1
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7    7
    7    7    7    8
CYCLES        68
START        001 1928
OUTNODES       9
    2    3    5  100  101  102  103  104  200
OUTLINKS      16
   13   23   34   36   45   58   86   60   30   31   32   10   47   33   72   54
OUTEVAP
DBOUT    S
$PHYSYS
RESERV         2  RESWTRIB                  10    2
      0.0     707.0      70.0     709.0     703.0     712.0    2084.0     715.0
   3495.0     717.0    6499.0     720.0    9117.0     722.0   12258.0     724.0
  18039.0     727.0   20369.0     728.0
  800  0.0   801  0.0
RESERV         3  RES-A                     10    2
      0.0     700.0     822.0     706.0    1954.0     709.0    5522.0     715.0
   7131.0     717.0   11035.0     721.0   14832.0     724.0   17822.0     726.0
  21463.0     728.0   25905.0     730.0
  800 .992   801  1.0
RESERV         5  RES-MDREC                  4    2
      0.0    695.80     31.45    697.63    132.70    699.45    265.80    700.68
  800 .992   801  1.0
IRRIGAT      100  BLOK1A                     0                   3157.        1.
IRRIGAT      101  BLOK1B                     0                   1295.        1.
IRRIGAT      102  BLOK4                      0                   1012.        1.
IRRIGAT      103  BLOK2                      0                   3440.        1.
IRRIGAT      104  BLOK3                      0                   2023.        1.
WITHDR       200  RTFLO
NATCHL        36  WTRIB                      3    6
NATCHL        58  DSMDREC                    5    8
NATCHL        86  KEN-UPR                    8    6
NATCHL        60  KEN-LWR                    6    0
DIVCHL        10  SUPPLYSPILL                1    0              10.00
DIVCHL        13  RDSUPPLY                   1    3               4.00
DIVCHL        23  NATWTRIB                   2    3               0.50
DIVCHL        31  TOBLK1B                    3  101              10.00
DIVCHL        34  TOJUNC4                    3    4              10.00
DIVCHL        30  TOBLOK1A                   4  100              10.00
DIVCHL        45  TORESMDREC                 4    5              10.00
DIVCHL        32  TOBLOK4                    5  102              10.00
DIVCHL        47  TOJUNC7                    4    7              10.00
DIVCHL        33  TOBLOK2                    7  103              10.00
DIVCHL        72  TORETFLO                   7  200              10.00
DIVCHL        54  TOBLOK3                    5  104              10.00
JUNCTION       4  BLOK1ATO
```

```
JUNCTION      8
JUNCTION      6  WTRIBMOUTH
JUNCTION      7  BLOK2JUNC
CTLSTR           BLOK1B                  31    3    9   CC
       0.0    715.00      0.2    715.41      0.6    715.80      1.0    716.49
       1.2    716.96      1.8    718.79      2.4    721.32      3.4    723.00
       4.0    728.00
CTLSTR           BLOK1A4&2               34    3    9   CC
       0.0    715.00      0.6    715.56      2.0    716.00      3.4    716.33
       5.2    716.70      6.0    717.00      7.0    718.25      8.0    728.00
       9.0    730.00
$PENSYS
RESERV   1    RESERVOIR           1    1    1
       2.0
     300.0
    2  RESERVOIR   1
    0      728.     707.
RESERV   2    RESERVOIR           1    1    2
       3.0
      10.0     200.0
    3  RESERVOIR   5
    0     728.5     728.2      715.
   61     728.5     728.2      715.
  105     728.5     728.5      715.
  244     728.5     728.5      715.
  301     728.5     728.2      715.
RESERV   3    RESERVOIR           1    1    1
     500.0
     300.0
    5  RESERVOIR   1
    0    700.68    699.45
IRRIGAT  1    IRRIG               5    1
       20.
  100  BLOK1A      1
    1      1.00
  101  BLOK1B      1
    1      1.00
  102  BLOK4       1
    1      1.00
  103  BLOK2       1
    1      1.00
  104  BLOK3       1
    1      1.00
WITHDR   1    RETFLO              1    1
  200
       0.0
      21.0
NATCHL   1    RIPARIAN            4    1    0
       5.0
   36  WTRIB       1
    1       50.       0.
   58  DS MDREC    1
    1       50.       0.
   86  KEM-UPR     1
    1       50.       0.
   60  KEM-LWR     1
    1       50.       0.
DIVCHL   1    CANALS              6
   10  SLYSPILL    1
    1      10.0
   13  RDSUPPLY    1
    1       4.0
   23  NATWTRIB    3
```

```
   1       0.0
 121       0.5
 152       0.0
  34  TOJUNC4     3
   1       0.0
 106      10.0
 301       0.0
  45  TOMDREC     3
   1       0.0
 106      10.0
 301       0.0
  47  TOMDREC     3
   1       0.0
 106      10.0
 301       0.0
DIVCHL   2    IRRGAT              5
  30  TOBLOK1A    1
   1      10.0
  31  TOBLOK1B    1
   1      10.0
  32  TOBLOK4     1
   1      10.0
  33  TOBLOK2     1
   1      10.0
  54  TOBLOK3     1
   1      10.0
DIVCHL   3    RETFLO              1
  72  TORETFLO    1
   1      10.0
$WATDEM
MINOR         3
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008     0.008     0.008     0.008     0.008
     0.008     0.008     0.008     0.008
MINOR         2 LICWTRIB
MINOR         5 LICKENCK
IRRIGAT     100 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     101 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     102 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     103 *BLOK328       C C C
       1.0
       0.0
       1.0
IRRIGAT     104 *BLOK328       C C C
       1.0
       0.0
       1.0
MAJOR       200 *RET328
$WATSUP
INSTOR        2                                       707.00
```

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INSTOR        3                                          728.20
INSTOR        5                                          699.45
INFLNOD       1 RDINFLO4         0
INFLNOD       2 NATWTRIB         0
INFLNOD       5 NATKENCK         0
INFLNOD     200 INFL328          0
EVAP        800 EVP ACAD
PRPT        801 PG  ACAD
$LAGDAT
$ENDFILE
```

APPENDIX F

Overview of Ecological Issues
M.D. of Acadia No. 34

Prepared by Ursus Ecosystem

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

EXECUTIVE SUMMARY

The Municipal District of Acadia #34 is examining the feasibility of constructing a water supply system to provide irrigation water to irrigable lands within the southern portion of the Municipality. URSUS Ecosystem Management Ltd. (URSUS) was contracted to provide an overview of ecological issues and follow-up requirements. A reconnaissance site visit was undertaken on 16 November 2004. URSUS' two senior biologists visited potential irrigation sites in the southern portion of the MD of Acadia by truck and on foot. Notes were taken on habitat conditions at 26 sites and representative photographs were taken. Landsat 7 satellite data (July 1999) and with a 30-m resolution, was used to classify native versus non-native lands in the study area. Soil landscape mapping data was used to map soil types and landforms in the study area. Lists of plant and vertebrate Species at Risk were developed to identify species with potential to occur in the study area.

The study area is located entirely within the Dry Mixedgrass Subregion of the Grassland Region of Alberta (AEP 1994). Three Ecodistricts (sub-groupings of Natural Subregions) are found within the study area: the Acadia Valley Plain (282.3 km^2); the Bindloss Plain (52.3 km^2); and, the Oyen Upland (19.0 km^2). AGRASID mapping identified 50 soil-landscape models (SLM) in the Study Area. SLMs provide information on soil subgroup, soil drainage/texture and landform. The study area is comprised of approximately 85% dominant or co-dominant Chernozemic soils, 15% Regosolic soils and less than one percent is waterbody.

Vegetation in the study area has been significantly altered from its native state by historic and current agricultural practices. Approximately 41% of the study area remains in a predominantly native condition. Most of the native lands occur in the central, western and southern portions of the study area. Mixed grassland comprised mainly of Spear grasses (*Stipa* spp.) and Wheat grasses (*Agropyron* spp.) characterize native upland habitats in the study area. Permanent wetlands are very rare in the study area. The richest and most [botanically and structurally] diverse vegetation occurs along active floodplains of the Red Deer River. Rare plant occurrence potential is high in the study area. Twenty-five occurrences of 16 rare plants were reported from a search be conducted by the Alberta Natural Heritage Information Center (Rintoul 2005) for 8 Townships in the vicinity of the study area. Rare plants in the study area are most likely to be found in association with the following habitats:

Dry, eroded valley wall and ravine slopes;
Alkaline flats and blowout features (Solonetzic soils);
Wet meadows;
Sandy soils and especially dunes; and,
Poplar and Manitoba Maple woodland along major river valleys.

As many as 37 rare plant communities have potential to occur in the study area. Rare plant communities have potential to occur in all major habitat types but are particularly prevalent in floodplain (riparian) landforms, wetlands, and dunes/blowouts.

A total of 40 vertebrate Species at Risk have potential to occur within the boundaries of the Study Area. These include 24 birds, 7 mammals, 5 reptiles and 4 amphibians. Alberta government records indicate the known occurrence of many Species at Risk within and adjacent to the study area: Burrowing Owl, Ferruginous Hawk, Loggerhead Shrike, Northern Leopard Frog, Western Hognose Snake, Plains Spadefoot, Canadian Toad, Plains Garter Snake, Prairie Rattlesnake, Bullsnake, Long-billed Curlew, Swainson's Hawk, Short-eared Owl and Ord's Kangaroo Rat.

Sport fish that occur in the lower Red Deer River system include northern pike (Esox lucius), walleye (Sander vitreus), sauger (Stizostedion canadense), mooneye (Hiodon tergisus), lake whitefish (Coregonus clupeaformis), yellow perch (Perca flavescens), burbot (Lota lota), lake sturgeon (Acipenser fulvescens), mountain whitefish (Prosopium williamsoni), goldeye and quillback (Carpiodes cyprinus). Goldeye are

considered the most numerous sport fish. During the late 90's to the present, angler creels have revealed a broader distribution of game fish throughout this system than recorded in previous years. In addition, sauger numbers have increased within the angler harvest. Less is known about the presence and distribution of game fish in the very remote lower reaches of the Red Deer River between Hwy 36 and the Saskatchewan border.

Environmentally Significant Areas (ESAs) in the M.D. of Acadia include a variety of upland, wetland and river valley sites, some of which are of provincial or national significance. Three ESAs occur within the boundaries of the study area: 1) Red Deer River – Bindloss/Empress Terraces; 2) Dune Point Springs; and, 3) Red Deer River – Alkali Creek/Dune Point. (Refer to Figure 8-1).

Rare landforms in the study area include: water basins, high relief hummocky terrain, meander floodplain, and confined (terraced) floodplain. These rare landforms occupy approximately 3.7% of the study area. It appears that the current project description avoids all of these landforms. No additional follow-up is required.

Riparian topography in the study area is limited to meander floodplains, and low-relief confined floodplains. Typical vegetation is willow shrubland, which occurs in areas such as Kennedy's Coulee and along the Red Deer River. Wildlife diversity and abundance is high in these limited areas of riparian habitat. The majority of the proposed development appears to avoid riparian areas. One notable exception is the water pipeline from the Red Deer River to Reservoir 1A. This pipeline has potential to affect riparian vegetation in the meander floodplain of the Red Deer River. It is recommended that a major focus of wildlife and species at risk inventory and assessment for this project occur in the area of the pipeline affecting the Red Deer River. Any other smaller scale riparian areas affected by linear features should receive additional inventory focus.

Potential effects on fish from the proposed development include water withdrawals for irrigation and potential for erosion from pipeline construction on the Bow River floodplain. The latter effect can be mitigated through timing restrictions. In terms of effects of water withdrawals, we recommend working closely with Alberta Fish and Wildlife and the Alberta Conservation Association to determine current water volume status with respect to fisheries requirements.

Permanent wetlands are a very scarce resource in the study area. It is beyond the scope of this study to inventory and map seasonal/intermittent wetlands. We recommend that during more detailed planning phases of this study, wetlands be identified and mapped in a 200 to 300-m corridor surrounding the proposed pipeline alignments, and within irrigation blocks. In spite of their rarity, wetlands offer unique and productive habitat for wildlife including some species at risk. Impacts to wetlands, including seasonal varieties, should be avoided.

All major native habitat types in the study area have potential to support federally and provincially listed Species at Risk (SAR). Important habitats for SAR include: floodplains/riparian woodland and shrubland; seasonal wetlands; lightly grazed native grasslands; dunes/blowouts; and, steep, eroded channel banks. The aspects of the development with greatest potential for impacts on SAR are flooding of Reservoir A1, which is located in a predominantly native valley wall/confined floodplain landform; and the water pipeline from the Red Deer River to Reservoir A1. The latter is also located through primarily native habitat in an area of particularly high wildlife and habitat diversity. It is recommended that Species at Risk field surveys be conducted with particular focus on the two areas mentioned above.

The study area has high potential to support rare plants and rare plant communities. The aspects of the development with greatest potential for impacts on rare botanical features are flooding of Reservoir A1 and the supply pipeline from the Red Deer River to Reservoir A1. Both of these areas are located in predominantly native habitat. It is recommended that rare plant and plant community surveys be conducted prior to development with particular focus on the two area mentioned above.

Featured wildlife species in the study area include mule deer, white-tailed deer and antelope. The most important habitat for these species is the valley floodplain of the Red Deer River. Construction should be avoided during the birthing and rearing season for these species (i.e. May and June). Ground surveys for antelope should be conducted as part of Species at Risk inventory and assessment – both in the Red Deer River valley and the Reservoir 1A area.

The two ESAs with greatest potential to be affected by the proposed development are: Red Deer River – Bindloss/Empress Creek; and, Dune Point Springs. The water pipeline from the Red Deer River floodplain to Reservoir A1 transects both of these ESAs. The Red Deer River – Bindloss/Empress Creek ESA is nationally significant owing to unique habitats that include Plains cottonwood woodland; dense riparian shrubland; dune landforms; and, complex river terrace geomorphology. All of these land features are conducive to the occurrence of vertebrate Species at Risk, rare plants and rare plant communities.

1.0 INTRODUCTION

1.1 Background

The Municipal District of Acadia #34 wishes to examine the feasibility of constructing a water supply system to provide irrigation water to irrigable lands within the southern portion of the Municipality. The M.D. retained MPE Engineering Ltd. (MPE) to complete the feasibility study. URSUS Ecosystem Management Ltd. (URSUS) was contracted by MPE to provide an overview of ecological issues and follow-up requirements.

1.2 Objectives

The objectives of this study were:

- Identify and discuss ecological issues that may influence the proposed development including:
    - Rare and sensitive landforms and soil types
    - Riparian topography and vegetation
    - Stream/river impacts with fish-bearing habitat
    - Wetland habitats
    - Native habitats supporting Species at Risk (federal and provincial)
    - Rare plants and plant communities
    - Habitat for featured wildlife and fish species
    - Environmentally Significant Areas

- Identify and discuss approaches and costs for environmental impact assessment, mitigation and monitoring that may be required.

2.0 METHODS

2.1 Site Visit

A reconnaissance site visit was undertaken on 16 November 2004. URSUS' two senior biologists visited potential irrigation sites in the southern portion of the MD of Acadia by truck and on foot. These sites included the four reservoir options from the 1988 Acres study. Provincial Environmentally Significant Areas (ESAs) in the study area were also visited. Notes were taken on habitat conditions at 26 sites and representative photographs were taken.

2.2 Landscape Mapping

Landsat 7 satellite data (July 1999) and with a 30-m resolution, was used to classify native versus non-native lands in the study area. A supervised classification using Bands 3,4,5 was completed followed by visual separation of cultivated from native areas. AGRASID (2005) soil landscape mapping data was used to map soil types and landforms in the study area.

2.3 Vertebrate Species at Risk

A list of the status and abundance of vertebrate wildlife species known, or expected, to be resident during some portion of the year within the study area was developed using local, regional and provincial references (Semenchuk 1992; Russell and Bauer 2000; Smith 1993; Pattie and Fisher 1999), and the authors' experience. From this list, vertebrate species at risk were identified based on recent regulatory status documents (COSEWIC 2005; AEP 2000, 2001). Records from the Biodiversity/Species Observation Database (BSOD) within the townships encompassing the study area. Status and abundance definitions as well as risk definitions are presented below.

Status

S summer resident, migrates out of study area for the winter

W winter resident, present only during late fall, winter and early spring

R permanent resident, present year-round although not necessarily active during winter

Abundance

C common, detected whenever suitable habitat is investigated during an appropriate season

U uncommon, detected often, but not always, whenever suitable habitat is investigated during an appropriate season

S scarce, detected occasionally, but not usually, even when suitable habitat is investigated during an appropriate season

R rare, unexpected but could occur in any given year, would not generally be considered a regular component of the study area fauna

2.4 Rare Plants and Plant Communities

Rare plant and community records in the vicinity of the proposed development were obtained through a search conducted by the Alberta Natural Heritage Information Center (Rintoul 2005).

Rare plant and plant community ratings followed ANHIC criteria as follows:

- S1: 5 or fewer occurrences in the province or only a few remaining individuals or may be imperiled because some factor of its biology makes it especially vulnerable to extirpation.
- S2: 6-20 occurrences or with many individuals in fewer occurrences; or may be susceptible to extirpation because of some factor of its biology.
- S3: 21-100 occurrences, may be rare and local throughout its provincial range, or in a restricted provincial range (may be abundant in some locations or may be vulnerable to extirpation because of some factor of its biology).
- S4: apparently secure under present conditions, typically >100 occurrences but may be fewer with many large populations; may be rare in parts of its provincial range, especially peripherally.
- S5: demonstrably secure under present conditions, >100 occurrences, may be rare in parts of its provincial range, especially peripherally.

S1, S2, and a handful of S3 ranked species are considered sufficiently rare to be tracked by the Natural Heritage Information Centre. Habitat affiliations of potentially occurring rare plant species were derived from Kershaw et al. (2001). Rare plant communities with potential to occur in the study area were taken from Allen (2004).

Table 1. At Risk Definitions

(AEP 2000; AEP 2001; AEP 2002; ASRD 2004; COSEWIC 2005; SARA 2005)

Alberta Environmental Protection (AEP)

General Status

At Risk – any species known to be "At Risk" after formal detailed status assessment and designation as "Endangered" or "Threatened" in Alberta

May Be At Risk – any species that "May Be At Risk" of extirpation or extinction, and is therefore a candidate for detailed risk assessment.

Sensitive – any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.

Endangered Species Conservation Committee

Endangered – a species facing imminent extirpation or extinction.

Threatened – a species likely to become endangered if limiting factors are not reversed.

Special Concern – a species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Data Deficient – a species for which there is insufficient scientific information to support status designation.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

Endangered - a species facing imminent extirpation or extinction.

Threatened - a species likely to become endangered if limiting factors are not reversed.

Special Concern - a species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Not at Risk - a species that has been evaluated and found to be not at risk.

Indeterminate - a species for which there is insufficient scientific information to support status designation.

3.0 STUDY AREA OVERVIEW

3.1 Land Use

The study area (353.6 km^2) occurs within the White Area of the province. Figure 1 shows the study area location including irrigation options and ESAs. Dominant land uses within the study area are agricultural including annual cropland, improved pasture and native grassland used for cattle grazing. Land ownership is a mosaic of private holdings, Crown lease and Municipal lease.

3.2 Regional Ecological Conditions

The study area is located entirely within the Dry Mixedgrass Subregion of the Grassland Region of Alberta (AEP 1994). The Dry Mixedgrass Natural Subregion is characterized by undulating to rolling moraine and outwash parent materials (AEP 1994). The most common grasses are spear grass, wheat grass, and blue grama (Cottonwood Consultants 1991). Of the four Grassland Subregions, this Subregion contains the highest diversity of animal species. Dominant soils are Brown Chernozems, which are moderately- to well-drained. Slope values range from 0 to 30%. Elevations range from 600-m to 1300-m. Permanent streams although rare are well defined. The vegetation cover in this ecological region is herbaceous with approximately 40% of the land area cleared.

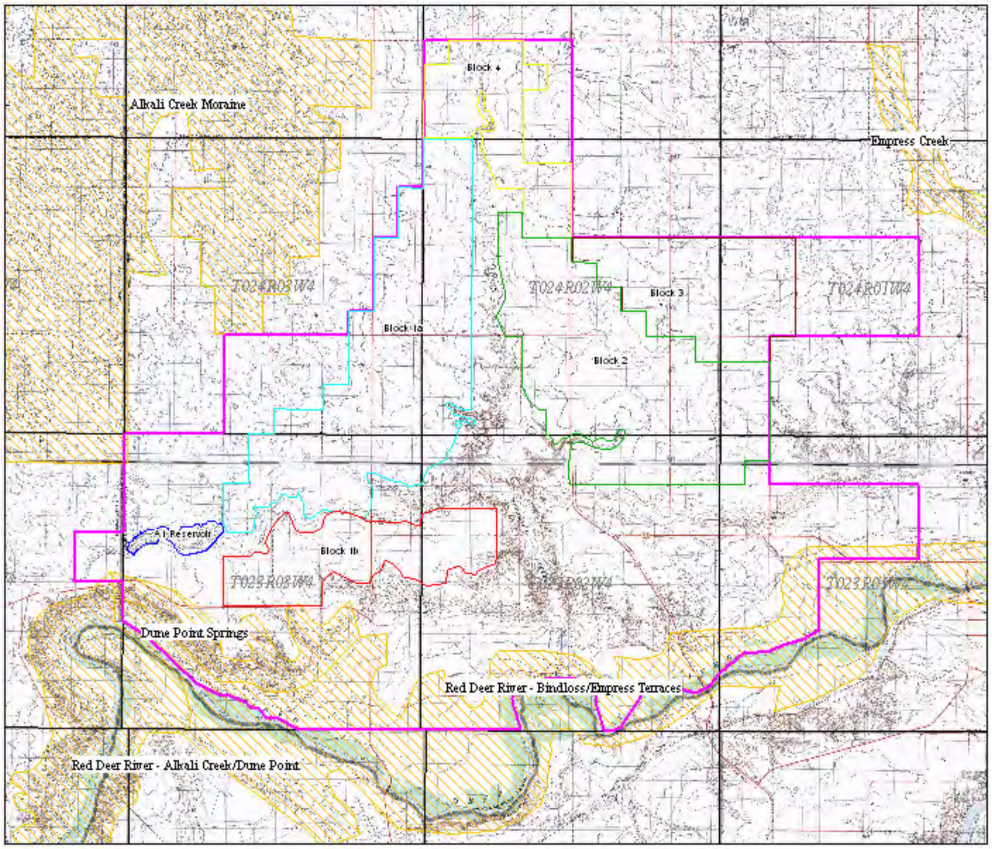
3.3 Study Area Ecological Conditions

3.3.1 Ecodistricts, Landforms and Soils

Ecodistricts are subdivisions of Natural Subregions based on distinctive Physiographic and/or geological patterns (Strong and Thompson 1995). Three Ecodistricts are found within the study area: the Acadia Valley Plain (282.3 km^2); the Bindloss Plain (52.3 km^2); and, the Oyen Upland (19.0 km^2). The Acadia Valley Plain Ecodistrict occupies the majority (79.8%) of the study area. The Oyen Upland Ecodistrict is found along the western edge of the study area while the Bindloss Plain occurs along the Red Deer River at the southern boundary. Ecological conditions associated with each Ecodistrict (Strong and Thompson 1995) are summarized in Table 2.

Table 2
Soil Landscape Models (SLM) in the MD of Acadia Irrigation Development Study Area.

SLM Code	Landform Description	Dominant Soil Subgroup	Dominant Drainage	Soil Texture	Hectares
ACCH1/U1h	undulating - high relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine to Medium	2075.7
ACV1/H1ld	Low relief hummocky terrain	Calcareous Brown Cher	Freely Drained	Fine	1890.3
ACV1/U1h	undulating - high relief	Calcareous Brown Cher	Freely Drained	Fine	6646.3
ACV1/U1l	undulating - low relief	Calcareous Brown Cher	Freely Drained	Fine	3041.1
ACV2/SC1hd	Valley with confined floodplain - high relief	Calcareous Brown Cher	Mostly Freely Drained	Fine	545.8
ACWD1/H1l	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	105.5
ACWD2/SC1l	Valley with confined floodplain - low relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	206.5
ACWD7/U1h	undulating - high relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	2830.2
BUCH11/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	1078.7
BUT4/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	228.8
BUT6/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	136.8
BVCH1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium to Coarse	427.1
BVCV1/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Coarse	143.6
BVCV4/I3m	Inclined to steep, single slopes - moderate relief	Orthic Brown Cher	Freely Drained	Coarse	88.8
BVCV5/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	799.5
BVL1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	136.1
BVL18/U1h	undulating - high relief	Orthic Brown Cher	Poor	Coarse	16.3
BVL6/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	436.0
BVL6/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Coarse	144.7
BVVG3/FP1	Meander floodplain	Orthic Brown Cher/Cumulic Regosol	Freely Drained	Medium to Coarse	0.3
CFCH1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	371.9
CFD11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	475.8
CHN11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	828.1
CHN4/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	143.0
CHN5/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	76.4
CHN6/U1l	undulating - low relief	Orthic Brown Cher	Freely Drained	Medium	1228.3
CVD1/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Coarse	56.8
CVD4/I3m	Inclined to steep, single slopes - moderate relief	Orthic Brown Cher	Freely Drained	Coarse	16.1
CVD8/SC1hr	Valley with confined floodplain - high relief	Orthic Brown Cher	Freely Drained	Coarse	199.2
FMT2/H1m	High relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	74.7
LYB6/SC1l	Valley with confined floodplain - low relief	Orthic Brown Cher	Freely Drained	Medium	96.2
MAB1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	1066.9
MAB1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	42.7
MAB5/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	123.9
MARO8/SC1h	Valley with confined floodplain - high relief	Orthic Brown Cher/Solonetzic Brown Cher	Freely Drained	Medium	873.8
MATV5/H1l	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Medium	1059.8
MATV5/H1lc	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Medium	232.2
RAM1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium to Coarse	131.8
RAM6/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium to Coarse	300.2
ROL17/U1h	undulating - high relief	Solonetzic Brown Cher	Freely Drained	Medium	319.1
VGR19/SC1l	Valley with confined floodplain - low relief	Cumulic Regosol	Freely Drained	Medium	468.7
VGR3/FP3	Confined floodplain, possibly terraced	Cumulic Regosol	Freely Drained	Medium	956.0
VGR3/U1h	undulating - high relief	Cumulic Regosol	Freely Drained	Medium	45.0
VGR6/FP1	Meander floodplain	Cumulic Regosol	Freely Drained	Medium	276.1
WDN11/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Fine	31.9
WDN11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Fine	520.9
WDN4/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Fine	634.1
ZUN16/I3h	Inclined to steep, single slopes - high relief	Orthic Regosol	Freely Drained	Undifferentiated	3045.6
ZUN16/I3hd	Inclined to steep, single slopes - high relief	Orthic Regosol	Freely Drained	Undifferentiated	666.3
ZWA1/W3	Water basin, may have water, > 65 Ha	Water body	Area Ponding	Undifferentiated	17.0



URSUS facilitating balanced land use decisions

URSUS Ecosystem Management Ltd.

Produced by Richard Ashton - Feb, 2005.

Kilometers

Scale 1 : 175,000

Figure 1. MD of Acadia No.34 (South) Irrigation Development Study Area

Study Area

Provincial Environmentally Significant Areas

Table 2. Ecological Characteristics of Ecodistricts in Study Area.					
Ecodistrict	*Surficial Material*	*Slope (%)*	*Drainage*	*Soil(s)*	*Vegetation*
Acadia Valley Plain	Lacustrine Plain (80%) Hummocky Moraine (20%)	0 – 30 0 – 5	Moderate	Brown Chernozems	Cleared Land/Herbaceous
Bindloss Plain	Glaciofluvial (80%) Hummocky Moraine (20%)	0 –15	Well; Moderate	Brown Chernozems	Herbaceous/Cleared Land
Oyen Upland	Hummocky Morainal Upland	0 – 30	Moderate	Brown Chernozems; Dark Brown Chernozems	Herbaceous; Cleared Land

AGRASID mapping identifies 50 soil-landscape models in the Study Area (Figure 2). SLMs provide information on soil subgroup, soil drainage/texture and landform. In Appendix 1 this information is provided for each of the SLMs mapped in Figure 2. The soil description is a composite of dominant (>60%), co-dominant (30% - 60%) or significant (10% - 30%) soils that occur in the polygon. The study area is comprised of approximately 85% dominant or codominant Chernozemic soils, 15% Regosolic soils and less than one percent is waterbody. The dominant Chernozems are mostly in one of two subgroups, the most common is Orthic Brown, followed by Calcareous Brown and a small amount in the Solonetzic Brown subgroup. The dominant Regosols are all within the Cumulic subgroup. The less common "significant" soils are comprised of the same soils types that occur in the "dominant/codominant" class as well as six other soil subgroups. The least common are Orthic Regosols, found only in branches of one valley in the East central part of the study area. Next most common are Brown Solodized Solonetz to the North and Orthic Humic Gleysols found in low lying stream valleys.

Glacial landforms are the most common (74%) in the study area and include mainly high relief undulating and low relief hummocky morainal (Appendix 2 –Photo #1) and glacio-lacustrine terrain. Water erosional features comprise the remainder of the landforms and include floodplains (Appendix 2 – Photo #2), terraces, meander bends and rivers/streams (10%). Water basins (17-ha), high relief hummocky terrain (75-ha), meander floodplain (256-ha), and confined (terraced) floodplain (956-ha) and are the least prevalent landform types.

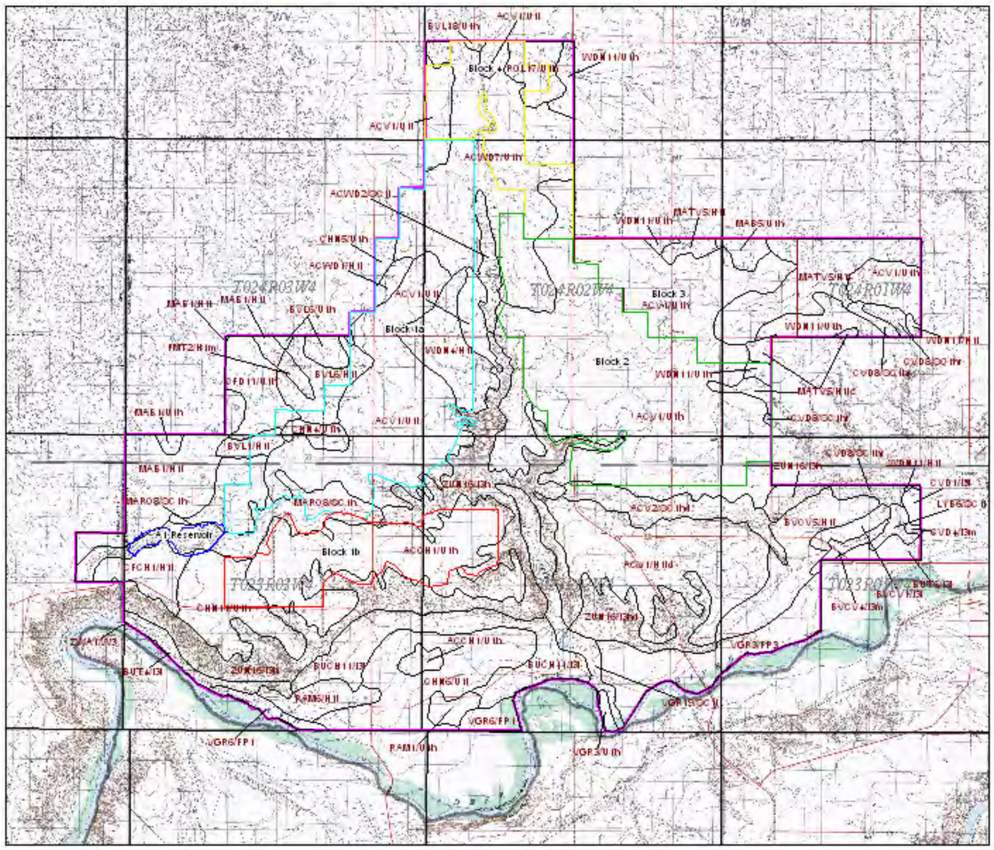


Figure 2. MD of Acadia No.34 (South)
Irrigation Development Study Area
Soil-Landscape Mapping

URSUS
facilitating balanced land-use decisions

URSUS Ecosystem Management Ltd.

Kilometers

Scale 1 : 175,000

Produced by Richard Ashton - Feb, 2005.

Study Area

3.3.2 Vegetation Cover

Vegetation in the study area has been significantly altered from its native state by historic and current agricultural practices. According to remote sensing analysis (Landsat7 imagery - 1999) approximately 41% of the study area remains in a predominantly native condition (Figure 3). Most of the native lands occur in the central, western and southern portions of the study area. Mixed grassland comprised mainly of Spear grasses (*Stipa* spp.) and Wheat grasses (*Agropyron* spp.) characterize native upland habitats in the study area. Shallow ravines associated with valley walls support low growing shrubs such as Buckbrush (*Symphoricarpos occidentalis*), Rose (*Rosa acicularis*) and Shrubby Cinquefoil (*Potentilla fruticosa*). Permanent wetlands are very rare in the study area and in the Dry Mixedgrass subregion as a whole (Cottonwood Consultants 1983, 1991). The majority of the wetlands in the study area are intermittent wet meadows (Appendix 2 – Photo #3) that are subject to flooding only for three or four weeks during spring.

Valley habitats occur along the Red Deer River and in association with larger creek valleys such as Kennedy's Coulee (Appendix 2 – Photo #4) and Empress Creek. Ephemeral stream courses (Appendix 2 – Photo #5) also support typical valley vegetation. The richest and most [botanically and structurally] diverse vegetation occurs along active floodplains of the Red Deer River. These include dense shrub thickets of Sandbar Willow (*Salix lutea*), *Populus deltoides*, *Betula occidentalis*, *Shepherdia argentea*, Rose and Buckbrush. Emergent vegetation characterized by bulrush and cattail are found in abandoned river channels. Some treed stands dominated by *Populus deltoides* occur (Appendix 2 – Photo #6). Wildlife diversity is highest along river valleys and well-defined creek valleys and coulees because of the diverse vegetation in these areas.

3.3.3 Rare Plants and Communities

We requested that a rare element occurrence search be conducted by the Alberta Natural Heritage Information Center (Rintoul 2005) for 8 Townships in the vicinity of the study area. The geographic area searched included Townships 23 and 24, Ranges 1, 2 and 3 and Township 22 Ranges 2 and 3 all west of the 4th meridian. Twenty-five occurrences of 16 rare plants were reported. These species as well as their ranking and habitat affiliations are listed below:

Ambrosia acanthicarpa	Open sandy places/dunes	S2
Anagallis minima	Moist soil/flooded areas	S1/S2
Aster pauciflorus	Alkaline flats/salt marshes	S2
Astragalus kentrophyta var kentrophyta	Hard-packed soils/blowouts	S1/S2
Astragalus lotiflorus	Hard-packed soils/blowouts	S2
Astragalus purshii	Blowouts/sand plains	S2
Bidens frondosa	Moist ground/ditches	S1
Calylophus serrulatus	Sandy prairies and dunes	S2
Carex parryana var parryana	Moist meadows/salt flats	S1/S2
Chenopodium subglabrum	Sand dunes	S1
Eriogonum cernuum	Sandy soils/dunes	S2
Oenothera flava	Clay flats/slough edges	S2
Orobanche ludoviciana	Moist woods/coulees	S2
Oryzopsis micrantha	Dry open slopes	S2
Osmorhiza longistylis	Stream woodlands	S2
Parietaria pensylvanica	Moist woods/coulees	S2
Shinnersoseris rostrata	Sandy banks/dunes	S2

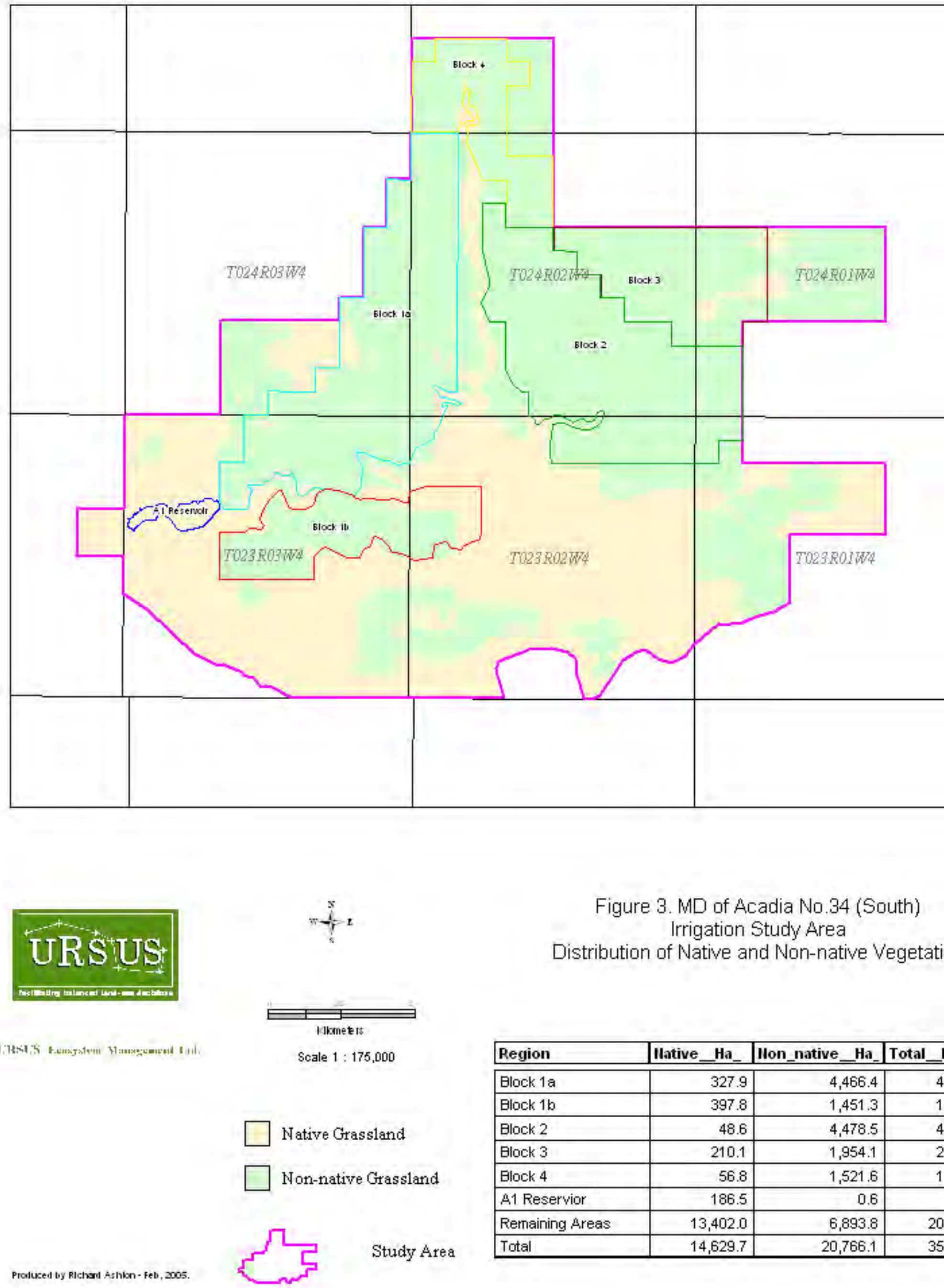


Figure 3. MD of Acadia No.34 (South)
Irrigation Study Area
Distribution of Native and Non-native Vegetation

Region	Native__Ha_	Non_native__Ha_	Total__Ha_
Block 1a	327.9	4,466.4	4,794
Block 1b	397.8	1,451.3	1,849
Block 2	48.6	4,478.5	4,527
Block 3	210.1	1,954.1	2,164
Block 4	56.8	1,521.6	1,578
A1 Reservior	186.5	0.6	187
Remaining Areas	13,402.0	6,893.8	20,296
Total	14,629.7	20,766.1	35,395

Detailed rare plant surveys have not been undertaken for this assessment. As such there are likely a number of rare plant sites have not yet been recorded. Based on review of potential rare plant distribution and occurrence we have identified rare plants other than those listed above that have potential to occur in the habitats representative of the study area (Appendix 3). Rare plant occurrence is often based on micro-site habitat conditions so we are not able to predict precisely which rare plants may occur. Based on plant searches on other projects the number of actual rare plant species found is a small percentage (usually <10%) of the number that could potentially occur.

Rare plants in the Dry Mixedgrass Subregion are most likely to be found in association with the following habitats:

- Dry, eroded valley wall and ravine slopes;
- Alkaline flats and blowout features (Solonetzic soils);
- Wet meadows;
- Sandy soils and especially dunes; and,
- Poplar and Manitoba Maple woodland along major river valleys.

As many as 37 rare plant communities have potential to occur in the study area. These communities are as follows:

Forest Woodland

- Manitoba Maple/Chokecherry (*Acer negundo/Prunus virginiana*) S1S2
- Plains Cottonwood/Red Osier Dogwood (*Populus deltoides/Cornus stolonifera*) S2S3
- Plains Cottonwood/Wild Licorice-Wire Rush (*P.deltoides/Glycyrrhiza lepidota/Juncus balticus*) S2S3
- Plains Cottonwood/Buckbrush (P. deltoides/Symphoricarpos occidentalis) S2S3
- Plains Cottonwood/Recent Alluvial (*P. deltoides*/recent alluvial) S1S3

Shrubland

- Silver Sagebrush/Green Needlegrass-Western Wheatgrass (*Artemisia cana/Stipa viridula-Pascopyrum smithii)* S2S3
- Peach-leaved Willow (*Salix amygdaloides*) S1S2
- Greasewood/Western Wheatgrass (*Sarcobatus vermiculatus/ P. smithii*) S2S3
- Greasewood/Silt Dune Shrubland (Sarcobatus vermiculatus/silt dune shrubland) S1

Shrub Herbaceous

- Silver Sagebrush/Western Wheatgrass/Northern Wheatgrass (*A. cana/P. smithii-Elymus lanceolatus*) S2S3
- Silver Sagebrush/wheatgrasses/Nuttal's Atriplex (*A. cana/P. smithii-E. lanceolatus/Atriplex nuttallii)* S2S3
- Silver Sagebrush/Needle-and-thread (*A. cana/Stipa comata*) S2S3
- Silver Sagebrush/Needle-and-thread-Sand Grass (*A. cana/S. comata-Calamovilfa longifolia*) S2S3
- Silver Sagebrush/Western Porcupine Grass-Sedge (*A. cana/S. curtiseta-Carex* spp.) S1S2

Herbaceous

- Sand Grass-Needle-and-thread (*C. longifolia-S. comata*) S3
- Northern Wheatgrass-Plains Muhly (*E. lanceolatus-Muhlenbergia cuspidata*) SP
- Northern Wheatgrass-Western Wheatgrass (*E. lanceolatus-P. smithii*) S2?
- Northern Wheatgrass-Needle-and-thread (*E. lanceolatus-S.comata*) S1S2
- Fowl Manna Grass (*Glyceria striata*) SU
- Scratch Grass-Nevada Bulrush-Saltgrass (Muhlenbergia asperifolia-Scirpus nevadensis-Distichlis stricta) S1S2
- Saltgrass-Western Wheatgrass (*D. stricta-P. smithii*) S2
- Western Wheatgrass-Prairie Sagewort (*P. smithii-Artemisia ludoviciana*) S1S2
- Western Wheatgrass-Blue Grama (*P. smithii-Bouteloua gracilis*) S1
- Western Wheatgrass-Needle-and-thread-Blue Grama (*P.smithii-S.comata-B. gracilis*) S2S3
- Nuttall's Salt Meadow Grass (*Puccinella nuttalliana*) S3?
- Wild Begonia (*Rumex venosus*) S2S3
- Silver Sagebrush-Nuttalls' Atriplex (*A. cana/Atriplex nuttallii*) S2S3
- Long-leaved Sagewort-Rabbitbrush (Artemisia longifolia-Chrysothamnus nauseosus) S1
- Dwarf Fleabane-Moss Phlox-Yellow Umbrella Plant (*Erigeron radicatus-Phlox hoodii-Eriogonum flavum*) S1
- Creeping Juniper/Junegrass-Yellow Umbrella Plant (Juniperus horizontalis/Koeleria macrantha-Eriogonum flavum) S1S2
- India Ricegrass-Canada Wild Rye (*Oryzopsis hymenoides-Leymus canadensis*) S2?
- Nevada Bulrush-(Seaside Arrowgrass) (*S. nevadensis – Seaside Arrowgrass*) S2S3
- Alkali Cord Grass – (Western Wheatgrass) (*Spartina gracilis-P. smithii*) S2S3
- Sand Dropseed - semi-active dune (*Sporobolus cryptandrus*) S2
- Seaside Arrow-grass (*Triglochin maritima*) S2
- Widgeon-Grass (*Ruppia cirrhosa*) S2
- Common Mare's Tail-White Water Crowfoot-Water Starwort (*Hippurus vulgaris-Ranunculus circinatus-Callitriche* spp.) SU

Rare plant communities have potential to occur in all major habitat types but are particularly prevalent in flooplain (riparian) landforms, wetlands, and dunes/blowouts.

3.3.4 Vertebrate Species at Risk

A total of 40 Species at Risk have potential to occur within the boundaries of the Study Area (Table 3). These include 24 birds, 7 mammals, 5 reptiles and 4 amphibians. The timing (16 November 2004) and brevity of the field visit (16 November 2004) precluded observation of many species. However at least 11 Sharp-tailed Grouse flushed from brush at NAD27 568235 5650501 and 33 Pronghorn were observed approximately 12-km S of Acadia Valley in stubble along Hwy 41.

Table 3.
Vertebrate Species at Risk with potential to occur in the M.D. of Acadia Irrigation Development Study Area

Common Name	Scientific Name	Status	Abundance	At Risk Designation			
				Alberta		COSEWIC	SARA Schedule
				General	ESCC		
Sharp-tailed Grouse	*Tympanuchus phasianellus*	R	U	Sensitive			
Pied-billed Grebe	*Podilymbus podiceps*	S	S	Sensitive			
Horned Grebe	*Podiceps auritus*	S	S	Sensitive			
American Bittern	*Botaurus lentigenosis*	S	S	Sensitive			
Great Blue Heron	*Ardea herodias*	S	S	Sensitive			
Black-crowned Night-Heron	*Nycticorax nycticorax*	S	S	Sensitive			
Swainson's Hawk	*Buteo swainsoni*	S	C	Sensitive			
Ferruginous Hawk	*Buteo regalis*	S	U	At Risk	Threatened	Special Concern	3
Golden Eagle	*Aquila chrysaetos*	S	S	Sensitive		Not at Risk	
Prairie Falcon	*Falco mexicanus*	S	U	Sensitive		Not at Risk	
Upland Sandpiper	*Bartramia longicauda*	S	U	Sensitive			
Long-billed Curlew	*Numenius americanus*	S	U	May Be At Risk	Special Concern	Special Concern	1
Black Tern	*Chlidonias niger*	S	S	Sensitive		Not at Risk	
Burrowing Owl	*Athene cunicularia*	S	S	At Risk	Threatened	Endangered	1
Short-eared Owl	*Asio flammeus*	S	S	May Be At Risk		Special Concern	3
Common Nighthawk	*Chordeiles minor*	S	C	Sensitive			
Pileated Woodpecker	*Dryocopus pileatus*	S	S	Sensitive			
Loggerhead Shrike	*Lanius ludovicianus*	S	U	Sensitive	Special Concern	Threatened	2
Sprague's Pipit	*Anthus spragueii*	S	U	Sensitive	Special Concern	Threatened	1
Brewer's Sparrow	*Spizella breweri*	S	S	Sensitive			
Lark Bunting	*Calamospiza melanocorys*	S	U	Sensitive			
Grasshopper Sparrow	*Ammodramus savannarum*	S	U	Sensitive			
Baird's Sparrow	*Ammodramus bairdii*	S	U	Sensitive		Not at Risk	

Table 3.
Vertebrate Species at Risk with potential to occur in the M.D. of Acadia Irrigation Development Study Area

Common Name	Scientific Name	Status	Abundance	At Risk Designation			
				Alberta		COSEWIC	SARA Schedule
				General	ESCC		
Bobolink	*Dolichonyx oryzivorus*	S	S	Sensitive			
Western Small-footed Bat	*Myotis ciliolabrum*	R	U	Sensitive			
Olive-backed Pocket Mouse	*Perognathus fasciatus*	R	S	Sensitive			
Ord's Kangaroo Rat	*Dipodomys ordii*	R	S	May Be At Risk	Endangered	Special Concern	3
Long-tailed Weasel	*Mustela frenata*	R	C	May Be At Risk		Not at Risk	
American Badger	*Taxidea taxus*	R	U	Sensitive	Data Deficient	Not at Risk	
Bobcat	*Lynx rufus*	R	S	Sensitive			
Pronghorn	*Antilocapra americana*	R	U	Sensitive			
Plains Spadefoot	*Spea bombifrons*	R	U	May Be At Risk		Not at Risk	
Great Plains Toad	*Bufo cognatus*	R	S	May Be At Risk	Data Deficient	Special Concern	1
Canadian Toad	*Bufo hemiophrys*	R	S	May Be At Risk	Data Deficient	Not at Risk	
Northern Leopard Frog	*Rana pipiens*	R	U	At Risk	Threatened	Special Concern	1
Western Hognose Snake	*Heterodon nasicus*	R	S	May Be At Risk			
Bullsnake	*Pituophis melanoleucus*	R	U	Sensitive		Data Deficient	
Wandering Garter Snake	*Thamnophis elegans*	R	C	Sensitive			
Plains Garter Snake	*Thamnophis radix*	R	C	Sensitive			
Prairie Rattlesnake	*Crotalus viridis*	R	U	May Be At Risk	Data Deficient		

Table 3.
Vertebrate Species at Risk with potential to occur in the M.D. of Acadia Irrigation Development Study Area

Common Name	Scientific Name	Status	Abundance	At Risk Designation			
				Alberta		COSEWIC	SARA Schedule
				General	ESCC		
Sharp-tailed Grouse	*Tympanuchus phasianellus*	R	U	Sensitive			
Pied-billed Grebe	*Podilymbus podiceps*	S	S	Sensitive			
Horned Grebe	*Podiceps auritus*	S	S	Sensitive			
American Bittern	*Botaurus lentigenosis*	S	S	Sensitive			
Great Blue Heron	*Ardea herodias*	S	S	Sensitive			
Black-crowned Night-Heron	*Nycticorax nycticorax*	S	S	Sensitive			
Swainson's Hawk	*Buteo swainsoni*	S	C	Sensitive			
Ferruginous Hawk	*Buteo regalis*	S	U	At Risk	Threatened	Special Concern	3
Golden Eagle	*Aquila chrysaetos*	S	S	Sensitive		Not at Risk	
Prairie Falcon	*Falco mexicanus*	S	U	Sensitive		Not at Risk	
Upland Sandpiper	*Bartramia longicauda*	S	U	Sensitive			
Long-billed Curlew	*Numenius americanus*	S	U	May Be At Risk	Special Concern	Special Concern	1
Black Tern	*Chlidonias niger*	S	S	Sensitive		Not at Risk	
Burrowing Owl	*Athene cunicularia*	S	S	At Risk	Threatened	Endangered	1
Short-eared Owl	*Asio flammeus*	S	S	May Be At Risk		Special Concern	3
Common Nighthawk	*Chordeiles minor*	S	C	Sensitive			
Pileated Woodpecker	*Dryocopus pileatus*	S	S	Sensitive			
Loggerhead Shrike	*Lanius ludovicianus*	S	U	Sensitive	Special Concern	Threatened	2
Sprague's Pipit	*Anthus spragueii*	S	U	Sensitive	Special Concern	Threatened	1
Brewer's Sparrow	*Spizella breweri*	S	S	Sensitive			
Lark Bunting	*Calamospiza melanocorys*	S	U	Sensitive			
Grasshopper Sparrow	*Ammodramus savannarum*	S	U	Sensitive			
Baird's Sparrow	*Ammodramus bairdii*	S	U	Sensitive		Not at Risk	
Bobolink	*Dolichonyx oryzivorus*	S	S	Sensitive			
Western Small-footed Bat	*Myotis ciliolabrum*	R	U	Sensitive			
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American Badger	*Taxidea taxus*	R	U	Sensitive	Data Deficient	Not at Risk	
Bobcat	*Lynx rufus*	R	S	Sensitive			
Pronghorn	*Antilocapra americana*	R	U	Sensitive			
Plains Spadefoot	*Spea bombifrons*	R	U	May Be At Risk		Not at Risk	
Great Plains Toad	*Bufo cognatus*	R	S	May Be At Risk	Data Deficient	Special Concern	1
Canadian Toad	*Bufo hemiophrys*	R	S	May Be At Risk	Data Deficient	Not at Risk	
Northern Leopard Frog	*Rana pipiens*	R	U	At Risk	Threatened	Special Concern	1
Western Hognose Snake	*Heterodon nasicus*	R	S	May Be At Risk			
Bullsnake	*Pituophis melanoleucus*	R	U	Sensitive		Data Deficient	
Wandering Garter Snake	*Thamnophis elegans*	R	C	Sensitive			
Plains Garter Snake	*Thamnophis radix*	R	C	Sensitive			
Prairie Rattlesnake	*Crotalus viridis*	R	U	May Be At Risk	Data Deficient		

BSOD records indicate the occurrence of many Species at Risk within and adjacent to the study area: Burrowing Owl, Ferruginous Hawk, Loggerhead Shrike, Northern Leopard Frog, Western Hognose Snake, Plains Spadefoot, Canadian Toad, Plains Garter Snake, Prairie Rattlesnake, Bullsnake, Long-billed Curlew, Swainson's Hawk, Short-eared Owl and Ord's Kangaroo Rat. Kennedy's Coulee appears to be a very important area for Species at Risk particularly snakes (a large denning complex occurs in the coulee) and Northern Leopard Frog. The Dune Point Springs and Red Deer River-Alkali Creek/Dune Point is also very important habitat for Species at Risk particularly Ord's Kangaroo Rat and amphibians (Canadian Toad, Plains Spadefoot and Northern Leopard Frog).

3.3.5 Fisheries

Existing fisheries data is outdated on the Lower Red Deer River. The last inventory on the lower Red Deer was conducted by Alberta Fish and Wildlife in 1990/1991. The Alberta Conservation Association recently initiated a two-phase sport fishery inventory/research project for the lower Red Deer River in 2003. Phase 1 was a scoping exercise to determine logistics, access, and reach length in the lower Red Deer River (Cooper and Council 2004). The purpose of Phase 2 is to determine the relative abundance and distribution of sport fish and non-sport fish species in the Lower Red Deer River.

Sport fish that occur in the lower Red Deer River system include northern pike (Esox lucius), walleye (Sander vitreus), sauger (Stizostedion canadense), mooneye (Hiodon tergisus), lake whitefish (Coregonus clupeaformis), yellow perch (Perca flavescens), burbot (Lota lota), lake sturgeon (Acipenser fulvescens), mountain whitefish (Prosopium williamsoni), goldeye and quillback (Carpiodes cyprinus). Goldeye are considered the most numerous sport fish. During the late 90's to the present, angler creels have revealed a broader distribution of game fish throughout this system than recorded in previous years. In addition, sauger numbers have increased within the angler harvest. Less is known about the presence and distribution of game fish in the very remote lower reaches of the Red Deer River between Hwy 36 and the Saskatchewan border.

Electro-fishing was conducted the Bindloss-Kennedy Coulee section of the Red Deer in the summer of 2004. Three sections along the River were sampled, each was 1-km long.

- First sampling point at Bindloss bridge
- Second sampling point 5-km downstream from bridge
- Third sampling point 3-km upstream from Kennedy Coulee

Fish species detected in 2004 included, Quillback, Walleye, Burbot, Sauger, Short-head red-horse, Long-nose sucker, Flat-head chub and Goldeye. This is the only data ever to be collected along this section of the River. ASRD did some fisheries work in 1990-91 but they did not sample downstream of Buffalo crossing.

3.3.6 Environmentally Significant Areas

Environmentally Significant Areas (ESAs) in the M.D. of Acadia include a variety of upland, wetland and river valley sites, some of which are of provincial or national significance (Cottonwood Consultants 1991). Three ESAs occur within the boundaries of the study area: 1) Red Deer River – Bindloss/Empress Terraces; 2) Dune Point Springs; and, 3) Red Deer River – Alkali Creek/Dune Point. Figure 1 shows the location of each ESA with respect to the alternative irrigation blocks and the study area as a whole. The significance and ecological features of each site are summarized below (Cottonwood Consultants 1991a; 1991b; Sweetgrass Consultants 1997).

Red Deer River – Bindloss/Empress Creek

- Nationally significant site located along the Red Deer River
- Extensive and diverse plains cottonwood forests
- Important dense shrub thicket breeding area for Loggerhead Shrikes and Sage Thrashers
- Diverse and abundant breeding songbird populations
- Massive river terraces with complex geomorphology (Appendix 2 – Photo #7)
- Active sand dunes with numerous rare plant species
- Key habitat for Antelope, Mule Deer and White-tailed Deer
- Important habitat for Sharp-tailed Grouse

Dune Point Springs

- Provincially significant site located on eroding slopes and coulees of Red Deer River (Appendix 2 – Photo #7)
- Extensive springs with numerous rare plant species
- Diverse and abundant alkali springs with numerous rare plant species
- Important nesting area for Loggerhead Shrike and Golden Eagle
- Complex geomorphology with diverse coulee woodlands, shrublands and grasslands
- Key habitat for Mule Deer and Antelope

Red Deer River – Alkali Creek/Dune Point

- Provincially significant site located along the Red Deer River valley
- Concentration of diverse river valley topography and vegetation including coulee woodlands, shrubbery, grasslands, rock outcrops, eroding slopes, sand dunes and riparian habitats
- Provincially significant populations of rare plants
- One of the few examples of gravelly dune blowouts in Alberta
- Most northerly and extensive population of Ord's Kangaroo Rats in Alberta
- Diverse and abundant alkali springs

4.0 POTENTIAL IMPACT ISSUES AND FOLLOW-UP REQUIREMENTS

4.1 Project Description

Construction and operation of the proposed irrigation scenarios has potential to impact vegetation and wildlife. Three scenarios are proposed to meet irrigation requirements. Each scenario includes the flooding of two reservoirs (1A and MD of Acadia Recreational Reservoir) and the irrigation of increasingly larger areas of irrigable lands based on increasing dam height and volume for reservoir 1A. Photos #8 and #9 of Appendix 2 show the Reservoir 1A site. Summarized below are the primary differences between the three scenarios:

Scenario 1

- Irrigates blocks 1A; 1B and 4 (Figure 1)
- Total irrigated areas is 5,500 ha
- A1 reservoir land area is 132 ha

Scenario 2

- Irrigates blocks 1A; 1B; 2 and 4 (Figure 1)
- Total irrigated areas is 8,900 ha
- A1 reservoir land area is 162 ha

Scenario 3

- Irrigates blocks 1A; 1B; 2; 3 and 4 (Figure 1)
- Total irrigated areas is 10,850 ha
- A1 reservoir land area is 219 ha

A gravity canal is proposed from Reservoir A1 to irrigation blocks 1A (Scenario 1) and 1A and 2 (Scenarios 2 and 3). This canal will be approximately 30 meters in width. The entire length of the proposed canal will transect previously cultivated lands. All 3 scenarios require a gravity pipeline from Reservoir 1A to irrigate Block 1B lands. The gravity pipeline will require a 15-m wide right-of-way and is 12-km in length. The entire length of the gravity pipeline will occur on previously cultivated lands. A pressure pipeline from the MD of Acadia reservoir will be required to irrigate Block 4 for Scenarios 1 and 2 and blocks 3 and 4 for Scenario 3. This pipeline will be located on either side of Kennedy's coulee with a length of 16.5-km for Scenarios 1 and 2 and 30-km for Scenario 3. A siphon will be used to feed irrigation Block #2 in Scenario 2 via gravity.

For all three scenarios a 48-inch pipeline will be constructed from the Bow River valley to reservoir 1A for 5-km with a 20-m wide open-cut. The majority of the water pipeline from the Bow River to Reservoir 1A will transect native lands.

4.2 Potential Ecological Issues and Proposed Follow-up

Below we discuss potential ecological issues and impacts and proposed follow-up strategies.

4.2.1 Rare and Sensitive Landforms and Soils

Rare landforms in the study area include: water basins, high relief hummocky terrain, meander floodplain, and confined (terraced) floodplain. These rare landforms occupy approximately 3.7% of the study area. It appears that the current project description avoids all of these landforms. No additional follow-up is required.

The soils that are most sensitive to erosion from pipeline construction are Solonetzic. The main concern with disturbance of soils having solonetzic horizons is the movement of salts out of the spoil and the length of time required to return to chemical values prior to disturbance. Recent research shows there is considerable natural leaching of soluble salts from the upper 15 to 20 cm of pipeline spoil. The rate varies with the amount of water movement through the soil. The amount of precipitation and the coarseness of the soil texture dictate the water movement. Other problem soils and geomorphic features can include surficial sand and gravel layers or lenses and consolidated bedrock. Salt-affected soils tend to be found in the plains region and associated with dry climate, saline-sodic bedrock or glacial tills from sodic bedrock. The occurrence of salt-affected soils may be higher in groundwater discharge areas. The two-lift process for soil handling is the standard procedure for the majority of pipeline work (cultivated lands). The concept is to preserve the organic rich surface layer. The depth of the 1st lift depends on the thickness of local topsoil and can vary from 10 to 30cm. Solonetzic soils are uncommon in the study area occupying 1,193-ha or 3.4% of the study area. Avoidance of these soils is recommended. If this is not possible then the mitigation measures outlined above are recommended.

4.2.2 Riparian Topography and Vegetation

Riparian topography in the study area is limited to meander floodplains, and low-relief confined floodplains. Typical vegetation is willow shrubland, which occurs in areas such as Kennedy's Coulee and along the Red Deer River. Wildlife diversity and abundance is high in these limited areas of riparian habitat. The majority of the proposed development appears to avoid riparian areas. One notable exception is the water pipeline from the Red Deer River to Reservoir 1A. This pipeline has potential to affect riparian vegetation in the meander floodplain of the Red Deer River.

It is recommended that a major focus of wildlife and species at risk inventory and assessment for this project occur in the area of the pipeline affecting the Red Deer River. Any other smaller scale riparian areas affected by linear features should receive additional inventory focus.

4.2.3 Fisheries Resources

Potential effects on fish from the proposed development include water withdrawals for irrigation and potential for erosion from intake construction in the river, and pipeline construction on the Red Deer River floodplain. The latter effect can be mitigated through timing restrictions. In terms of effects of water withdrawals, we recommend working closely with Alberta Fish and Wildlife and the Alberta Conservation Association to determine current water volume status with respect to fisheries requirements.

4.2.4 Wetlands

Permanent wetlands are a very scarce resource in the study area. It is beyond the scope of this study to inventory and map seasonal/intermittent wetlands. We recommend that during more detailed planning phases of this study, wetlands be identified and mapped in a 200 to 300-m corridor surrounding the proposed pipeline alignments, and within irrigation blocks. In spite of their rarity, wetlands offer unique and productive habitat for wildlife including some species at risk. Impacts to wetlands, including seasonal varieties, should be avoided.

4.2.5 Native Habitats with Vertebrate Species at Risk

All major native habitat types in the study area have potential to support federally and provincially listed Species at Risk (SAR). Important habitats for SAR include: floodplains/riparian woodland and shrubland; seasonal wetlands; lightly grazed native grasslands; dunes/blowouts; and, steep, eroded channel banks. The aspects of the development with greatest potential for impacts on SAR are flooding of the 1A reservoir, which is located in a predominantly native valley wall/confined floodplain landform and the water pipeline from the Red Deer River and the 1A reservoir. The latter is also located through primarily native habitat in an area of particularly high wildlife and habitat diversity. It is recommended that Species at Risk field surveys be conducted with particular focus on the two areas mentioned above.

4.2.6 Rare Plants and Rare Plant Communities

The study area has high potential to support rare plants and rare plant communities. The aspects of the development with greatest potential for impacts on rare botanical features are flooding of the 1A reservoir and the water pipeline from the Red Deer River and the 1A reservoir. Both of these areas are located in predominantly native habitat. It is recommended that rare plant and plant community surveys be conducted prior to development with particular focus on the two area mentioned above.

4.2.7 Habitat for Featured Wildlife Species

Featured wildlife species in the study area include mule deer, white-tailed deer and antelope. The most important habitat for these species is the valley floodplain of the Red Deer River. Construction should be avoided during the birthing and rearing season for these species (i.e. May and June). Ground surveys for antelope should be conducted as part of Species at Risk inventory and assessment – both in the Red Deer River valley and the Reservoir 1A area.

4.2.8 Environmentally Significant Areas (ESA)

The two ESAs with greatest potential to be affected by the prposed development are: Red Deer River – Bindloss/Empress Creek; and, Dune Point Springs. The water pipeline from the Red Deer River floodplain to Reservoir 1A transects both of these ESAs. The Red Deer River – Bindloss/Empress Creek ESA is Nationally significant owing to unique habitats that include Plains cottonwood woodland; dense riparian shruland; dune landforms; and, complex river terrace geomorphology. All of these land features are conducive to the occurrence of vertebrate Species at Risk, rare plants and rare plant communities.

5.0 SUMMARY AND CONCLUSIONS

1. Approximately 60% of the study area has been subject to cultivation – with the majority of cultivation occurring in the northern portion of the study area.
2. Predominantly native lands occupy approximately 40% of the study area with large patches associated with the Red Deer River valley and Kennedy Coulee.
3. A large number of Species at Risk (40), rare plants (16+) and rare plant communities (37) have potential to occur in the study area
4. Areas with the greatest significance to both vertebrate Species at Risk and rare plants/plant communities are located along the Red Deer River floodplain and south-facing valley walls and within Kennedy's Coulee.
5. Nationally and provincially significant Environmentally Significant Areas (ESAs) occur in the southern portion of the study area along and adjacent to the Red Deer River valley.
6. The two aspects of the development most likely to conflict with native ecological features of importance are the water pipeline planned from the intake structure at the Red Deer River to Reservoir 1A and the flooding of Reservoir 1A.
7. Focussed vertebrate Species at Risk surveys as well as rare plant and plant community surveys will be required prior to development to assist in the development of mitigation measures. Particular areas of survey focus should be the Red Deer River – Bindloss/Empress Creek ESA and Dune Point Springs ESAs and the Reservoir 1A area.

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Appendix 1
Soil Landscape Models (SLM) in the MD of Acadia Irrigation Development Study Area.

SLM Code	Landform Description	Dominant Soil Subgroup	Dominant Drainage	Soil Texture	Hectares
ACCH1/U1h	undulating - high relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine to Medium	2075.7
ACV1/H1ld	Low relief hummocky terrain	Calcareous Brown Cher	Freely Drained	Fine	1890.3
ACV1/U1h	undulating - high relief	Calcareous Brown Cher	Freely Drained	Fine	6646.3
ACV1/U1l	undulating - low relief	Calcareous Brown Cher	Freely Drained	Fine	3041.1
ACV2/SC1hd	Valley with confined floodplain - high relief	Calcareous Brown Cher	Mostly Freely Drained	Fine	545.8
ACWD1/H1l	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	105.5
ACWD2/SC1l	Valley with confined floodplain - low relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	206.5
ACWD7/U1h	undulating - high relief	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Fine	2830.2
BUCH11/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	1078.7
BUT4/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	228.8
BUT6/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Medium	136.8
BVCH1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium to Coarse	427.1
BVCV1/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Coarse	143.6
BVCV4/I3m	Inclined to steep, single slopes - moderate relief	Orthic Brown Cher	Freely Drained	Coarse	88.8
BVCV5/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	799.5
BVL1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	136.1
BVL18/U1h	undulating - high relief	Orthic Brown Cher	Poor	Coarse	16.3
BVL6/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Coarse	436.0
BVL6/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Coarse	144.7
BVVG3/FP1	Meander floodplain	Orthic Brown Cher/Cumulic Regosol	Freely Drained	Medium to Coarse	0.3
CFCH1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	371.9
CFD11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	475.8
CHN11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	828.1
CHN4/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	143.0
CHN5/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	76.4
CHN6/U1l	undulating - low relief	Orthic Brown Cher	Freely Drained	Medium	1228.3
CVD1/I3l	Inclined to steep, single slopes - low relief	Orthic Brown Cher	Freely Drained	Coarse	56.8
CVD4/I3m	Inclined to steep, single slopes - moderate relief	Orthic Brown Cher	Freely Drained	Coarse	16.1
CVD8/SC1hr	Valley with confined floodplain - high relief	Orthic Brown Cher	Freely Drained	Coarse	199.2
FMT2/H1m	High relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	74.7
LYB6/SC1l	Valley with confined floodplain - low relief	Orthic Brown Cher	Freely Drained	Medium	96.2
MAB1/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium	1066.9
MAB1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	42.7
MAB5/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium	123.9
MARO8/SC1h	Valley with confined floodplain - high relief	Orthic Brown Cher/Solonetzic Brown Cher	Freely Drained	Medium	873.8
MATV5/H1l	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Medium	1059.8
MATV5/H1lc	Low relief hummocky terrain	Orthic Brown Cher/Calcareous Brown Cher	Freely Drained	Medium	232.2
RAM1/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Medium to Coarse	131.8
RAM6/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Medium to Coarse	300.2
ROL17/U1h	undulating - high relief	Solonetzic Brown Cher	Freely Drained	Medium	319.1
VGR19/SC1l	Valley with confined floodplain - low relief	Cumulic Regosol	Freely Drained	Medium	468.7
VGR3/FP3	Confined floodplain, possibly terraced	Cumulic Regosol	Freely Drained	Medium	956.0
VGR3/U1h	undulating - high relief	Cumulic Regosol	Freely Drained	Medium	45.0
VGR6/FP1	Meander floodplain	Cumulic Regosol	Freely Drained	Medium	276.1
WDN11/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Fine	31.9
WDN11/U1h	undulating - high relief	Orthic Brown Cher	Freely Drained	Fine	520.9
WDN4/H1l	Low relief hummocky terrain	Orthic Brown Cher	Freely Drained	Fine	634.1
ZUN16/I3h	Inclined to steep, single slopes - high relief	Orthic Regosol	Freely Drained	Undifferentiated	3045.6
ZUN16/I3hd	Inclined to steep, single slopes - high relief	Orthic Regosol	Freely Drained	Undifferentiated	666.3
ZWA1/W3	Water basin, may have water, > 65 Ha	Water body	Area Ponding	Undifferentiated	17.0

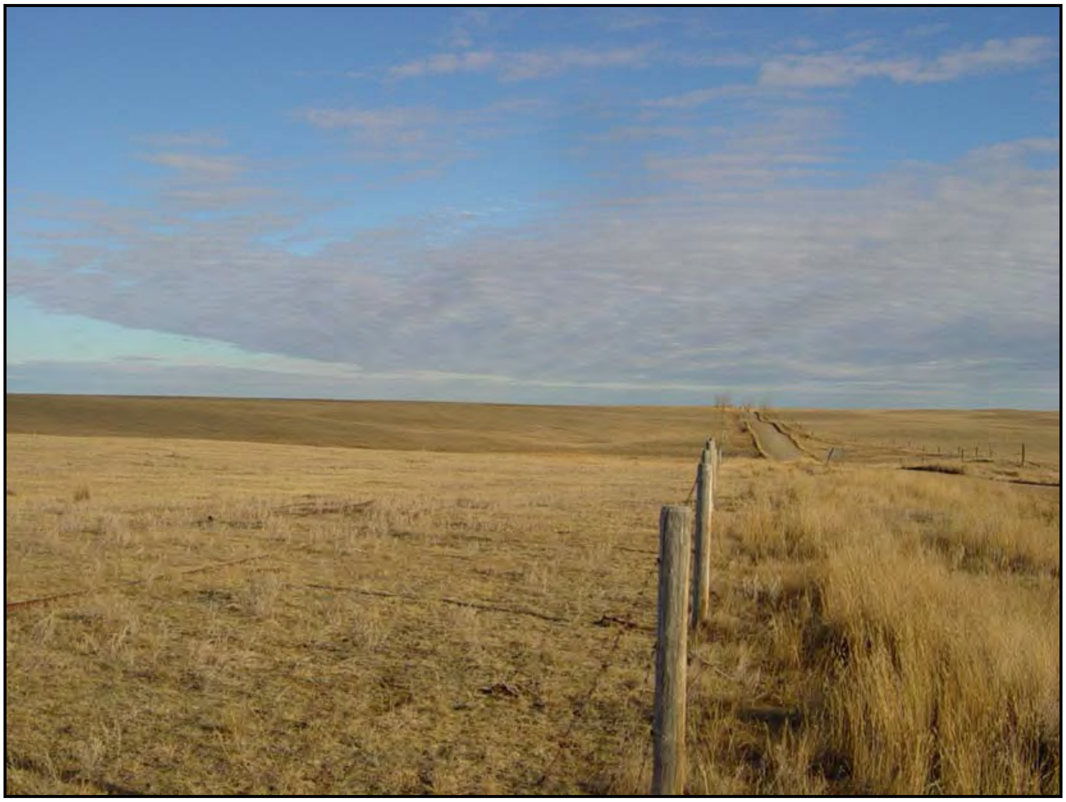


Photo 1. Low relief hummocky terrain – west-central edge of study area.

Photo 2. Lower floodplain of Kennedy's Cr.-Red Deer-Bindloss/Empress ESA


Photo 3. Seasonal wetland in hummocky moraine - western edge of study area.


Photo 4. Complex, high relief glacial topography of Kennedy's Coulee.

Photo 5. Riparian ponds and shrubland of Kennedy's Coulee.

Photo 6. Red Deer R. terrace with riparian woodland/shrubland (background).

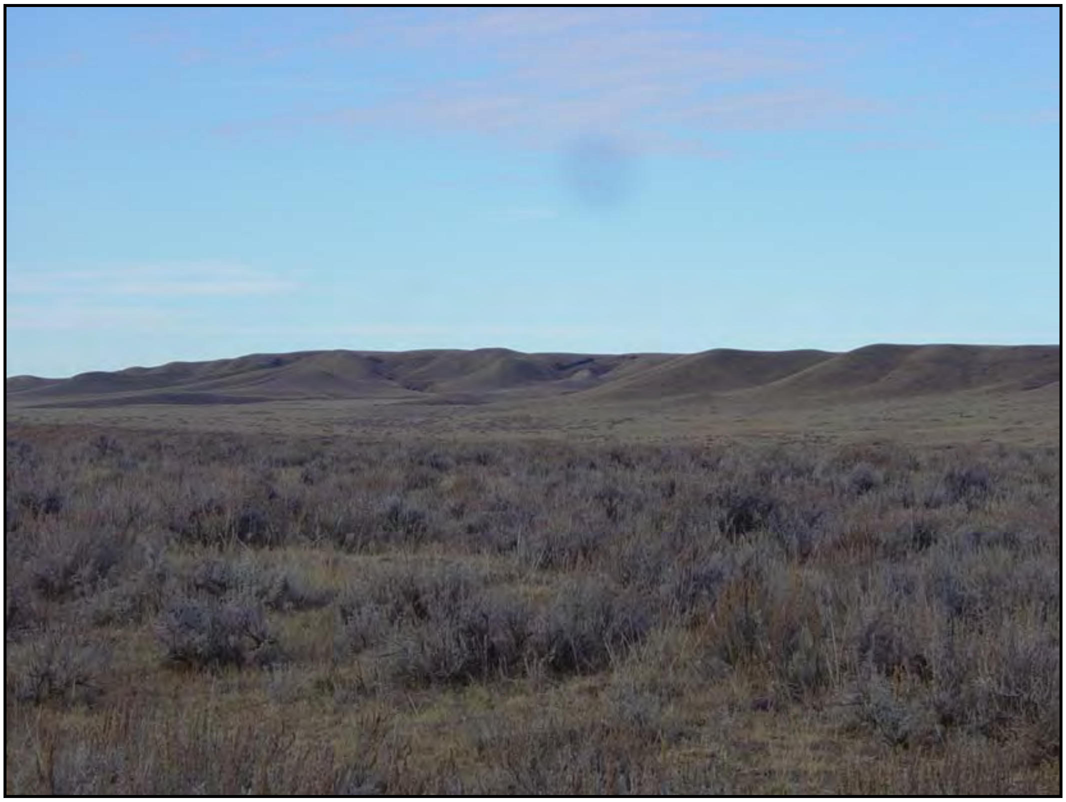


Photo 7. Red Deer-Bindloss/Empress Creek and Dune Point Springs ESAs.


Photo 8. Central area of Site of Reservoir 1A – looking west.

Photo # 9. Site of proposed Reservoir 1A – looking east.

Photo 10. Confined floodplain - northern portion of study area near “siphon”.

APPENDIX 3.
Rare Plants of the Dry Mixedgrass Natural Subregion with potential to occur in the MD of Acadia Irrigation Development Study Area.

Scientific Name	*Common Name*	SRank
Mannia fragrans	liverwort	S1
Riccia cavernosa	liverwort	S1
Aloina rigida	aloe-like rigid screw moss	S2
Bryum amblyodon		S1
Campylium polygamum		S3
Didymodon fallax	fallacious screw moss	S2
Pterygoneurum ovatum	hairy-leaved beardless moss	S1
Pterygoneurum subsessile		S1
Tortula caninervis		S1
Weissia controversa	green-cushioned weissia	S2
Jaffueliobryum raui		S1
Jaffueliobryum wrightii		S2
Pyrrhospora elabens		S1
Buellia turgescens		S1
Lecania cyrtella		S1
Lecanora crenulata		S1
Psora himalayana		S2
Sarcogyne regularis		S1
Staurothele elenkinii		S1
Psora tuckermanii		S2
Amaranthus californicus	Californian amaranth	S1
Osmorhiza longistylis	smooth sweet cicely	S2
Asclepias viridiflora	green milkweed	S1
Ambrosia acanthicarpa	bur ragweed	S2
Bidens frondosa	common beggarticks	S1
Coreopsis tinctoria	common tickseed	S2
Crepis atribarba	hawk's-beard	S2
Crepis occidentalis	small-flowered hawk's-beard	S2
Erigeron ochroleucus var scribneri	buff fleabane	S2
Erigeron radicatus	dwarf fleabane	S2
Hymenopappus filifolius	tufted hymenopappus	S2
Nothocalais cuspidata	prairie false dandelion	S1
Picradeniopsis oppositifolia	picradeniopsis	S1
Psilocarphus brevissimus var brevissimus	dwarf woollyheads	S2
Shinnersoseris rostrata	annual skeletonweed	S2
Stephanomeria runcinata	rush-pink	S2
Thelesperma subnudum var marginatum	greenthread	S1
Townsendia exscapa	low townsendia	S2
Aster pauciflorus	few-flowered aster	S2
Cryptantha minima	tiny cryptanthe	S1
Heliotropium curassavicum	spatulate-leaved heliotrope	S1
Arabidopsis salsuginea	mouse-ear cress	S1
Draba reptans	whitlow-grass	S1
Halimolobos virgata	slender mouse-ear-cress	S1
Rorippa tenerrima	slender cress	S1S2
Rorippa curvipes var truncata	blunt-leaved yellow cress	S1
Downingia laeta	downingia	S1S2
Cerastium brachypodum		S1
Spergularia salina	salt-marsh sand spurry	S2
Atriplex canescens	saltbush	SU
Atriplex powellii	Powell's saltbush	S1
Atriplex truncata	saltbush	S1
Chenopodium desiccatum	goosefoot	S1S2
Chenopodium subglabrum	smooth narrow-leaved goosefoot	S1
Chenopodium watsonii	Watson's goosefoot	S1

APPENDIX 3.
Rare Plants of the Dry Mixedgrass Natural Subregion with potential to occur in the MD of Acadia Irrigation Development Study Area.

Suaeda moquinii	Moquin's sea-blite	S2
Suckleya suckleyana	poison suckleya	S1
Hypericum majus	large Canada St. John's-wort	S2
Polanisia dodecandra	clammyweed	S2
Cuscuta gronovii	common dodder	S1
Elatine triandra	waterwort	S1
Astragalus kentrophyta var kentrophyta	prickly milk vetch	S1S2
Astragalus lotiflorus	low milk vetch	S2
Astragalus purshii	Pursh's milk vetch	S2
Ellisia nyctelea	waterpod	S2
Lycopus americanus	American water-horehound	S2
Tripterocalyx micranthus	sand verbena	S2
Fraxinus pennsylvanica	green ash	S1
Boisduvalia glabella	smooth boisduvalia	S2
Calylophus serrulatus	shrubby evening-primrose	S2
Camissonia andina	upland evening-primrose	S1
Camissonia breviflora	taraxia	S1
Oenothera flava	low yellow evening-primrose	S2
Orobanche ludoviciana	Louisiana broom-rape	S2
Eriogonum cernuum	nodding umbrella-plant	S2
Polygonum polygaloides ssp confertiflorum	Watson's knotweed	S2
Linanthus septentrionalis	linanthus	S2
Anagallis minima	chaffweed	S1S2
Lysimachia hybrida	lance-leaved loosestrife	S2
Ranunculus glaberrimus	early buttercup	S2
Potentilla paradoxa	bushy cinquefoil	S2
Potentilla plattensis	low cinquefoil	S1
Potentilla finitima	sandhills cinquefoil	S1
Bacopa rotundifolia	water hyssop	S1
Castilleja sessiliflora	downy paintbrush	S1
Parietaria pensylvanica	American pellitory	S2
Yucca glauca	soapweed	S1
Sagittaria latifolia	broad-leaved arrowhead	S1
Tradescantia occidentalis	western spiderwort	S1
Carex nebrascensis	Nebraska sedge	S2
Carex parryana var parryana	Parry's sedge	S1S2
Carex retrorsa	turned sedge	S2S3
Cyperus schweinitzii	sand nut-grass	S2
Cyperus squarrosus	awned nut-grass	S1
Eleocharis compressa var borealis	flattened spike-rush	SU
Scirpus pallidus	pale bulrush	S1
Elodea bifoliata	two-leaved waterweed	S1
Sisyrinchium septentrionale	pale blue-eyed grass	S2S3
Lilaea scilloides	flowering-quillwort	S1
Juncus confusus	few-flowered rush	S2S3
Aristida purpurea var longiseta	red three-awn	S1
Elymus virginicus	Virginia wild rye	S1
Hordeum pusillum	little barley	SH
Muhlenbergia asperifolia	scratch grass	S2
Munroa squarrosa	false buffalo grass	S1
Oryzopsis micrantha	little-seed rice grass	S2
Puccinellia cusickii	Cusick's salt-meadow grass	SU
Spartina pectinata	prairie cord grass	S1
Sphenopholis obtusata	prairie wedge grass	S2
Marsilea vestita	hairy pepperwort	S2

APPENDIX G

Water Quality Report

Municipal District of Acadia No. 34

Irrigation Development Study

Water Quality

Prepared by

Patsy Cross, Madawaska Consulting

February 2005

WATER QUALITY EXECUTIVE SUMMARY

Existing studies and background data were reviewed to determine the water quality characteristics of the Red Deer River and Kennedy Creek, to determine the suitability for irrigation, livestock watering and recreation and to evaluate the potential deterioration of water quality within the system.

The best database for the Red Deer River was at Bindloss, somewhat downstream of the withdrawal location. There were no data from Kennedy Creek, so data were compiled from four creeks which flow into the Red Deer River from the north side between Finnegan and Bindloss. Water quality for the Red Deer River and the 'surrogate' Kennedy Creek was generally acceptable for irrigation, livestock watering and recreation.

Deterioration in water quality through the system due to evaporation, surface runoff, erosion of saline soils and interaction with groundwater should not be significant enough to limit water usage for irrigation, livestock watering and recreational uses.

Salts will be increased in the system through evaporation in Reservoir A1 and along the canals as well as through drainage from saline lands, however the salinity increase should be small enough to remain below the irrigation guideline. If higher salinity is experienced, the limitation will depend on the salt sensitivity of the crops irrigated and the soil characteristics of the irrigated fields.

The contribution of local water to the reservoir through surface runoff and through pumping of water from the watershed, which accumulates upstream of the west dam of the reservoir, will contribute nutrients to the reservoir. Similarly, local runoff into the canals may introduce sediment, nutrients, bacteria and pesticides. The volume of local runoff from the watershed should be relatively small and efforts should be made in the watershed to reduce the impacts on water quality through the use of beneficial management practices on the land, including both livestock and cropping practices to reduce erosion and keep contaminants out of the canal and drainage water.

Recreational use of the reservoirs will be affected by the nutrient / plant community development. Water level fluctuations in Reservoir A1 may affect the development of the shoreline weed population, but algal blooms will likely affect aesthetic sensibilities at some times. If development around the lake is contemplated, beneficial management practices should be employed to establish stable shorelines, reduce erosion and minimize inputs of nutrients, bacteria and pesticides.

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

The water quality portion of the study of irrigation development in the M.D. of Acadia required the following information.

> "Deterioration of water quality within the system related to: evaporation; mixing of diverted water with poor-quality surface runoff; introduction of mineral salts through erosion of saline soils comprising the conveyance system; and interaction between poor-quality groundwater and surface water."

This requirement is met through a review of existing studies and background data to determine the water quality characteristics of the Red Deer River and Kennedy Creek, an assessment of the information using relevant water quality guidelines to determine the suitability for irrigation, livestock watering and recreation and an evaluation of the potential deterioration of water quality within the system.

2.0 REVIEW OF EXISTING STUDIES

The following studies were reviewed for relevant water quality information:

- Red Deer River Corridor Integrated Management Plan - Parkland and Bow Region Environmental Resource Committees, 2000
- Comprehensive Study Report under the Canadian Environmental Assessment Act for Valley South Co-op Ltd. Water Pipeline Project - Agriculture and Agri-Food Canada, PFRA Southern Alberta Regional Office, Calgary, Alberta, 1999
- Salinity Mapping for Resource Management with the M.D. of Acadia, Alberta - Kwiatkowski, J. and C.R. King, Alberta Agriculture, Food and Rural Development, Conservation and Development Branch, 1998
- Water Quality Monitoring Data in Support of Modelling for Instream Flow Needs in the Red Deer River - W-E-R AGRA Ltd, Rapid Creek Water Works and Madawaska Consulting, 1993
- Water Quality Inventory / Database Interim Report - W-E-R Engineering Ltd, 1992
- Environmentally Significant Areas in the Palliser Region M.D. of Acadia No. 34 - Cottonwood Consultants Ltd, 1991
- The Impact of the Dickson Dam on Water Quality and Zoobenthos in the Red Deer River - Shaw, R.D. and A.M. Anderson, Alberta Environment, Environmental Quality Monitoring Branch, 1991
- An Overview of Water Quality in the Red Deer River Basin (1983 - 1984) - Cross, P.M., Alberta Environment, Environmental Quality Monitoring Branch, 1991
- Preliminary Investigation into Surface Water Quality in Berry and Sounding Creek Basins - Riddell, K.M. and D. Mikalson, Alberta Agriculture, Land Evaluation and Reclamation Branch, 1989
- Water Supply to the Special Areas Phase I Study Report - Acres International Limited, 1987

- Oyen - Youngstown Corridor Water Supply Study - Stanley Associates Engineering Ltd, 1985

Water quality information relevant to the downstream reaches of the Red Deer River was available in the 1991 Overview report as follows:

> "The Red Deer River is an alkaline, hard water system dominated by calcium and bicarbonate." "...very large and progressive increases in NFR [non-filterable residue / total suspended solids] occurred as the river traversed the highly erodible substrates of the lower basin (badlands). As a consequence, all water quality variables related to the particulate phase followed similar patterns."
>
> "Dissolved solids also increased in the lower basin reflecting the progressively more saline nature of tributaries and irrigation return flows in those reaches. Nutrients and coliform bacteria were significantly increased as a consequence of treated sewage discharges below Red Deer and Drumheller. Benthic algal standing crops increased below Red Deer but declined thereafter, possibly reflecting the combined effects of dissolved P [phosphorus] depletion, increased turbidity in the lower reaches, and substrate changes."
>
> "...burrowing organisms such as midges and worms became more important in downstream direction as the river became increasingly depositional in nature (i.e., silty, sandy substrates, slow water flow)."

Analysis of the impacts of the Dickson Dam on water quality concluded:

> "...minimum winter dissolved oxygen concentrations have increased along the entire length of the river, although post-impoundment concentrations below 5 mg/L are still recorded occasionally downstream of the city of Red Deer, including at the Alberta-Saskatchewan border."
>
> "Flow regulation has resulted in lower levels of calcium, magnesium, bicarbonate, sulphate, total dissolved solids, conductance, alkalinity, and hardness as far downstream as the Alberta-Saskatchewan border. In addition seasonal fluctuations of these variables have been reduced.. Calcium carbonate and magnesium carbonate co-precipitation within Gleniffer Lake is the probable cause for the decreased levels of most of these variables, although dilution by groundwater may also play a role."

Although no water quality information was available for Kennedy Creek, the study of Berry and Sounding Creeks provide some relevant conclusions as follows:

> "Results of the preliminary investigation into water quality in Berry Creek indicate the water is "Safe" for irrigation according to Alberta Agriculture Water Quality Guidelines. Water diverted from the Red Deer River into Berry Creek should not be subject to sufficient salt loading to cause water quality to deteriorate into an unsafe category of irrigation.

Results of a preliminary investigation into water quality in Sounding Creek suggest water quality varies over the length of the creek. Water in the headwaters region of Sounding Creek falls into the "Safe" category for irrigation suitability according to Alberta Agriculture Water Quality Guidelines. Water in the middle section of Sounding Creek is classified as "Hazardous" or "Possibly Safe" for irrigation according to Alberta Agriculture Water Quality Guidelines. Groundwater discharge is a potential cause of the poor water quality observed in the middle sections of Sounding Creek.

Water diverted from the Red Deer River into Sounding Creek may be subject to deterioration in quality for irrigation purposes."

3.0 DATA COMPILATION

Although there were some impacts of the Dickson Dam on water quality in the lower reaches of the Red Deer River, these were deemed to be minor in the context of this data review. Therefore, all relevant historical data were collected for analysis. Water quality data collected from the Red Deer River near Bindloss were compiled from the historical database available from the 1992 inventory report, 1993 monitoring data and a data request from Alberta Environment (i.e. sites AL05CK0001 from 1982 to 1992 and AB05CK0037 to 0043 from 1992 to 2000).

Data compilation included the following measures:

- Duplicate samples on the same date were deleted
- Procedure codes were combined for the same parameter
- Field pH and conductivity values were infilled with lab values
- Turbidity NTU values were infilled with JTU values
- Values less than detection were treated as one half the detection limit
- Values greater than a number (coliforms) were treated as that number

Data were unavailable from Kennedy Creek therefore data were compiled from the following creeks as surrogate information for Kennedy Creek:

- Alkali Creek - AL05CK1200
- Blood Indian Creek - AL05CK1000, AB05CK0010
- Berry Creek - AL05CH3000, AB05CH0010 to 0120
- Bullpound Creek - AB05CG0015

The four creeks used as surrogates drain into the Red Deer River from the north, between Finnegan and Bindloss.

The compiled data statistics are given in Tables 1 and 2.

4.0 PRELIMINARY ASSESSMENT OF WATER QUALITY

4.1 Suitability for Irrigation

Data were compared to Alberta and Canadian water quality guidelines for irrigation to determine acceptability for irrigation use (Alberta Environment 1999, Surface Water Quality Guidelines for Use in Alberta; CCME (Canadian Council of Ministers of the Environment) 1999, Canadian Environmental Quality Guidelines).

Water quality for the Red Deer River at Bindloss (Table 1) was generally acceptable for irrigation, with mean values all within guideline values. The few exceptions included 1 of 69 results for total coliform bacteria, 21 of 134 results for fecal coliform bacteria and 3 of 87 results for sulphate.

Water quality for the creeks serving as surrogates for Kennedy Creek (Table 2) was generally acceptable for irrigation, with mean values all within guideline values. The few exceptions included 7 of 24 results for conductivity, 6 of 22 results for fecal coliform bacteria, 4 of 13 results for sodium adsorption ratio and 2 of 8 results for manganese.

Although the water quality data indicate that the water is suitable for irrigation, there was an indication of some potential, occasional issues with salinity and bacteria. The salinity issues relate to the use of water on sensitive crops or on soils susceptible to permeability problems. The bacteria issues relate to the use of water on raw produce. Although the issues may be minor, the land chosen for irrigation and the crop selection will mitigate any potential impacts.

4.2 Factorings Affecting Water Quality Through the System

Another consideration in the assessment of the suitability of the source water taken from the Red Deer River for irrigation is the change in water quality through the completed system. Several factors can affect this water quality as it moves through the conveyance system including:

- Evaporation from the canal and reservoirs will concentrate the salts, increasing the salinity.
- Surface water runoff from snowmelt and rainfall could dilute the salinity or add soil particles, bacteria, nutrients, salts and pesticides depending on the land use and salinity.
- Any groundwater to surface water interaction would likely add salts to the irrigation water.

Reservoir A1 provides water storage for the irrigation system. The reservoir will provide some settling of sediments from the Red Deer River and will also develop the biological community of a reservoir. Upon filling, the reservoir will experience an initial trophic surge as organic matter is submerged and the reservoir environment is being established. The water quality in the reservoir will have a substantial ongoing supply of nutrients to support a productive plant community. The reservoir will likely be eutrophic and subject to summer algal blooms. The contribution of local water to the reservoir through surface runoff and through pumping of water from the watershed, which accumulates upstream of the west dam of the reservoir, will contribute nutrients to the reservoir.

Evaporation in the reservoir and contribution from local runoff and the upstream watershed will contribute salts to the reservoir. Depending on reservoir mixing, there may be a salinity gradient with higher salinity at the end furthest from the end with the inlet and outlet structures. The degree of impact from evaporation and runoff on the suitability for irrigation is not expected to be limiting. If higher salinity is experienced, the limitation will depend on the salt sensitivity of the crops irrigated and the soil characteristics of the irrigated fields.

Water distribution via open canal systems (Secondary A canal) is not expected to change water quality too dramatically. Water quality in the open canal systems will be affected by evaporation and surface runoff. This has the potential to increase salts, sediments, nutrients, bacteria and pesticides. The volume of local runoff from the watershed should be relatively small. Efforts should be made in the watershed to reduce the impacts on water quality through the use of beneficial management practices on the land, including both livestock and cropping practices to reduce erosion and keep contaminants out of the canal and drainage water.

Salinity mapping indicates that most of the salinity in the M.D. of Acadia is depression bottom with two small areas of contact and slope change salinity and three areas of coulee bottom salinity (one along Kennedy Creek). The canals do not appear to cross areas with identified salinity. The upstream end of Secondary A canal appears to skirt identified depression salinity and contact and slope change salinity areas to the northeast of Reservoir A1.

Water quality along the canals will have sufficient nutrients to promote plant community development. This could impede the flow and withdrawal of water. Therefore, canals and withdrawals should be designed to minimize this effect where possible.

Pipeline distribution of water via Secondary B and Secondary C canals should have negligible effect on water quality.

Groundwater is not expected to have a significant influence on surface water quality within the irrigation distribution system.

The initial expected trophic surge in Reservoir A1 upon filling, will transfer poorer water quality to Acadia Reservoir. Over the longer term however, Reservoir A1 could well have a slightly lower productivity than Acadia Reservoir, based on the relatively poorer water quality measured in 'surrogate' Kennedy Creek than in the Red Deer River. The contribution of water into Acadia Reservoir via Secondary A canal may have a slightly beneficial influence on salinity, but will increase the nutrient loading and may increase the algal response in Acadia Reservoir.

4.3 Suitability for Livestock Watering and Recreation

Data were compared to guidelines for livestock watering and recreation, since these may be a secondary water use within the system.

Water quality for the Red Deer River at Bindloss was generally acceptable for livestock watering and recreation, with mean values all within guideline values. The few exceptions included; for livestock watering, 19 of 78 results for phenolics (all pre-March 1986) and for recreation, 8 of 134 results for fecal coliform bacteria.

Water quality for the creeks serving as surrogates for Kennedy Creek was generally acceptable for livestock watering and recreation, with mean values all within guideline values with the exception of phenolics for livestock watering. The other few exceptions were for recreation, 5 of 22 results for fecal coliform bacteria and 2 of 10 results for E. coli.

Recreational use of the reservoirs will be affected by the nutrient / plant community development. Water level fluctuations in Reservoir A1 may affect the development of the shoreline weed population, but algal blooms will likely affect aesthetic sensibilities at some times. If development around the lake is contemplated, beneficial management practices should be employed to establish stable shorelines, reduce erosion and minimize inputs of nutrients, bacteria and pesticides.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Water quality in the Red Deer River (source water) and 'surrogate' Kennedy Creek (surface runoff) appears to be suitable for irrigation, livestock watering and recreational uses, based on available data.

Reservoir A1 will initially experience a trophic surge and in the longer term should be a relatively productive water body with seasonal algal blooms.

Deterioration in water quality through the system due to evaporation, surface runoff, erosion of saline soils and interaction with groundwater should not be significant enough to limit water usage for irrigation, livestock watering and recreational uses.

It is recommended that beneficial management practices are implemented in the watershed to minimize the movement of sediment, nutrients, bacteria and pesticides directly or via runoff into the reservoirs and canals.

Table 1 Water Quality at Red Deer River near Bindloss

		N	Mean	Minimum	Median	Maximum	Guidelines		
							Irrigation	Livestock	Recreation
Temperature	C	143	10.4	-0.2	10.3	24.5			
pH	Units	143	8.1	7.2	8.2	9.1			
Conductivity	mS/cm	143	0.47	0.29	0.45	0.96	1.0		
Alkalinity	mg/L	90	188	120	176	417			
Hardness	mg/L	77	200	117	190	425			
Dissolved Oxygen	mg/L	140	9.1	1.2	8.8	14.3			
Total Dissolved Solids	mg/L	90	280	165	269	589		3000	
Turbidity	NTU	96	76	1	31	900			
Total Nitrogen	mg/L	78	0.71	0.13	0.47	3.84			
Total Kjeldahl Nitrogen	mg/L	23	0.68	0.32	0.56	1.63			
Dissolved Kjeldahl Nitrogen	mg/L	7	0.60	0.08	0.52	1.40			
Ammonia	mg/L	109	0.05	<0.01	0.05	0.80			
Nitrate + Nitrite	mg/L	109	0.109	<0.003	0.005	0.800		100	
Total Phosphorus	mg/L	109	0.132	0.005	0.063	2.700			
Dissolved Phosphorus	mg/L	109	0.016	<0.003	0.009	0.263			
Orthophosphorus	mg/L	93	0.006	<0.002	0.002	0.192			
Total Organic Carbon	mg/L	91	7.7	2.0	6.2	48.4			
Total Inorganic Carbon	mg/L	4	39.8	36.0	37.1	49.0			
Dissolved Organic Carbon	mg/L	93	5.0	1.7	4.5	13.2			
Biochemical Oxygen Demand	mg/L	7	1.2	<0.1	1.1	3.9			
Phenolics	mg/L	78	0.002	<0.001	0.001	0.008		0.002	
Chlorophyll a	ug/L	75	13.3	<1	6.0	200.0			
Total Coliform Bacteria	#/100mL	69	73	0	11	2200	1000		1000
Fecal Coliform Bacteria	#/100mL	134	109	<1	14	5000	100		200
True Colour	Pt-Co units	79	23	<5	20	100			
Total Suspended Solids	mg/L	96	174	<1	46	3140			
Non-filterable Residue - Fixed	mg/L	79	170	<1	40	2860			
Potassium	mg/L	77	2.8	1.3	2.3	7.3			
Sodium	mg/L	77	25.1	1.5	24.9	52.0			
Calcium	mg/L	77	50.3	28.5	47.7	103.0		1000	
Magnesium	mg/L	77	18.2	10.1	17.2	40.8			
Sodium Adsorption Ratio		77	0.78	0.06	0.75	1.55	3		
Bicarbonate	mg/L	73	231	146	210	508			
Chloride	mg/L	77	4.8	<0.1	4.3	15.0			
Sulphate	mg/L	87	62	24	58	117	100 - 700	1000	
Fluroide	mg/L	75	0.16	0.06	0.16	0.26	1	1 - 2	
Reactive Silica	mg/L	77	3.7	1.0	3.6	9.5			
Cyanide	mg/L	78	0.003	<0.001	0.002	0.013			
E coli	#/100mL	51	193	3	20	5000			200
Copper	mg/L	16	0.006	0.003	0.005	0.016	0.2 - 1	0.5 - 5	
Iron	mg/L	6	2.822	2.377	2.725	3.483	5		
Lead	mg/L	16	0.0026	0.0022	0.0025	0.0032	0.2	0.1	
Zinc	mg/L	16	0.024	0.004	0.013	0.109	1 - 5	50	

Table 2 Water Quality at Selected Creeks

		N	Mean	Minimum	Median	Maximum	Guidelines		
							Irrigation	Livestock	Recreation
Temperature	C	19	17.3	0.8	19.5	24.1			
pH	Units	23	7.9	6.8	8.0	9.0			
Conductivity	mS/cm	23	0.84	0.09	0.71	2.08	1.0		
Alkalinity	mg/L	12	189	36	156	462			
Hardness	mg/L	8	125	30	114	244			
Dissolved Oxygen	mg/L	18	8.7	0.6	8.3	14.6			
Total Dissolved Solids	mg/L	12	481	68	333	1402		3000	
Turbidity	NTU	12	12	3	8	35			
Total Kjeldahl Nitrogen	mg/L	20	1.32	0.34	1.32	2.40			
Ammonia	mg/L	20	0.06	<0.01	0.05	0.29			
Nitrate + Nitrite	mg/L	20	0.089	<0.003	0.003	1.590		100	
Total Phosphorus	mg/L	20	0.168	0.017	0.088	0.911			
Dissolved Phosphorus	mg/L	8	0.032	0.012	0.019	0.081			
Orthophosphorus	mg/L	3	0.019	0.011	0.017	0.030			
Total Organic Carbon	mg/L	9	16.5	6.8	14.7	34.0			
Particulate Carbon	mg/L	3	7.4	4.3	7.9	10.0			
Dissolved Organic Carbon	mg/L	12	13.7	5.6	12.1	33.0			
Dissolved Inorganic Carbon	mg/L	3	90	79	81	110			
Biochemical Oxygen Demand	mg/L	3	2.1	1.5	2.2	2.7			
Phenolics	mg/L	12	0.005	<0.001	0.006	0.020		0.002	
Chlorophyll a	ug/L	3	3.0	0.8	3.4	4.8			
Total Coliform Bacteria	#/100mL	12	64	0	1	720	1000		1000
Fecal Coliform Bacteria	#/100mL	22	85	0	11	450	100		200
True Colour	Pt-Co units	9	56	<5	30	150			
Total Suspended Solids	mg/L	11	10	<1	6	33			
Potassium	mg/L	12	6.7	3.6	6.2	13.8			
Sodium	mg/L	12	90.0	16.5	59.0	295.0			
Calcium	mg/L	12	41.6	4.4	37.5	114.0		1000	
Magnesium	mg/L	12	25.8	2.1	19.9	71.0			
Sodium Adsorption Ratio		12	2.68	1.62	2.20	5.49	3		
Bicarbonate	mg/L	12	228	44	190	563			
Chloride	mg/L	12	8.5	1.4	5.3	43.0	100 - 700		
Sulphate	mg/L	12	194	17	112	608		1000	
Fluroide	mg/L	12	0.16	0.05	0.16	0.27	1	1 - 2	
Reactive Silica	mg/L	8	8.0	2.2	6.8	16.8			
E coli	#/100mL	10	114	12	100	260			200
Copper	mg/L	15	0.001	<0.001	0.001	0.004	0.2 - 1	0.5 - 5	
Iron	mg/L	14	0.831	0.059	0.395	2.630	5		
Lead	mg/L	6	0.0014	0.0001	0.0014	0.0025	0.2	0.1	
Zinc	mg/L	15	0.011	0.002	0.008	0.031	1 - 5	50	
Arsenic	mg/L	5	0.0043	0.0023	0.0039	0.0064	0.1	0.025	
Boron	mg/L	5	0.05	0.03	0.05	0.08	0.5 - 6.0	5	
Beryllium	mg/L	5	0.001	<0.001	0.001	0.001	0.1	0.1	
Cadmium	mg/L	5	<0.001	<0.001	<0.001	<0.001	0.0051	0.08	
Chromium	mg/L	9	0.001	<0.001	0.001	0.003			
Manganese	mg/L	9	0.14	0.05	0.13	0.28	0.2		
Nickel	mg/L	5	0.005	0.003	0.004	0.006	0.2	1	
Selenium	mg/L	5	0.0003	0.0002	0.0003	0.0004	0.02 - 0.05	0.05	
Vanadium	mg/L	5	0.003	<0.001	0.002	0.005			

APPENDIX H

Historical Resources Report

Bison

HISTORICAL RESOURCES OVERVIEW FORM

Bison Historical Services Ltd.
Archaeological and Historical Consultants
1A, 215 - 36th Avenue N.E. Calgary, AB T2E 2L4
Phone 403-283-8974, Fax 403-270-0575, www.bisonhistorical.com

Project Name: Irrigation Development HRO - M.D. of Acadia #34

File Opened: February 15, 2005 Historical Resources Division Project No. ____

Prepared by: Michelle Wickham/Thomas Head Archaeological Permit No. ____

[X] Key Contact: Bison Historical Services Ltd. Applicant's No.: 502-134

Applicant's Corporate Name: MPE Engineering [ ] Key Contact

Address: Suite 260, East Atrium 2635-37th Ave NE Calgary, AB., T1Y 5Z6

City Province Postal Code

Contact Person: Mike Breunig Title: ____

Telephone: (403) 250-1362 Fax: (403) 250-1518 e-mail: mbreunig@mpe.ab.ca

---

Agent's Corporate Name: N/A [ ] Key Contact

Address: ____

City Province Postal Code

Contact Person: ____ Title: ____

Telephone: ____ Fax: ____ e-mail: ____

Landowner: Currently unavailable

Address: ____

City Province Postal Code

Telephone: ____ Fax: ____ e-mail: ____

Nature of Project (all that apply)-Well [ ] Pipeline [ ] Access Rd [X] Other: Irrigation Development

Plan Attached [ ] MSL ____ PLA ____ LOC ____

Project Size (ha.): Currently unavailable Nearest Town: Town of Bindloss

NTS Mapsheet(s): 72 L/16 Bindloss, 72 M/1 Acadia Valley

Legals: Please see attached

HRO 05-018

Project Name Irrigation Development HRO - M.D. of Acadia #34

HRO 05-018

Reasons for Referral EIA [ ] Class I [X] Class II [ ] Sig. Site List [X] Other [ ]

HRV (if applicable) 4 & 5 Site(s) on Sig. Site List **Miner #3 Medicine Wheel EfOo-24; campsite/stone circle/cairn EfOn-23; cairn EfOm-61; cairn EfOn-141; scatter EgOn-21; stone circle/cairn EgOn-18**

Borden Block (s) EfOm=6; EfOn=142; EfOo=159; EgOm=19; EgOn=21; EgOo=1

Archaeological Sites in Section **EfOo**-95,94,22,21,20,92,93,15;**EfOn**-67,60,68,87,69,88,70,90,74,71,72,79,114;**EgOn**-14,19,20

Archaeological Sites in Adjacent Sections **EfOo**-54,55,159,23,24,114,91,115,13,26;**EfOn**-61,53,66,65,64,57,78,77,117,120,58,50,110,119,113,122,121,112,111,76;**EgOn**-10,15,18,21;**EgOm-1**

Archaeological Sites Impacted unsure

Historic Sites in Section none

Historic Sites in Adjacent Sections none

Historic Sites Impacted none

Previous Permits in General Area ASA 99-041,75-004,76-035,77-086,98-099,85-005,76-003,02-168,77-081,03-351,99-035,99-122,99-007,91-092,01-090,04-036,03-028,03-222,99-112;Mikkelborg, K. 2003;Wright, M.J. 1982; ASA CRM 078,090,081

Designated Sites

Designated/Significant Sites in Vicinity none

Designated/Significant Sites Impacted none

Palaeonological Sensitivity Yes HRV=5 Palaeontological HRO attached [ ]

Vegetation (all that apply) - see Natural Regions of Alberta or Strong and Leggat 1992

[X] Grassland	[ ] Parkland	[ ] Boreal Forest
[ ] Rocky Mountain	[ ] Foothills	[ ] Canadian Shield
[X] Cultivated	[ ] Bog	[ ] Other ________

Landform (all that apply) - see Shetsen 1987

[ ] Upland (name) ________	[ ] Hummocky Moraine	[ ] Dunes (Aeolian)
[X] Lacustrine/Glaciolacustrine	[X] Draped Moraine	[X] Fluvial
[ ] Esker	[ ] End Moraine	[X] Linear Feature
[X] Other Stagnation Moraine		

Drainage (all that apply)

[X] River (name) Red Deer	[X] Creek (name) Kennedy's Coulee
[ ] Major Meltwater Channel	[X] Minor meltwater Channel
[ ] Lake (name) ________	[ ] Wetland/Slough (temporary or permanent)
[X] Distance from Drainage	[X] <100m [ ] 100-250m [ ] 250-500m [X] >500m

Topography

[X] Flat [ ] Gently Rolling [X] Undulating [X] Hummocky

Hummocky Relief - see Shetsen 1987

[X] <3m [X] 3-10m [ ] 5-15m [ ] 5-20m

Sedimentation Potential

[X] Low [ ] Medium [ ] High

Aspect (visible from)

[X] North [X] East [X] South [X] West

Project Name Irrigation Development HRO - M.D. of Acadia #34

HRO 05-018

Evaluation The proposed irrigation feasibility study for M.D. of Acadia No. 34 is centred on all or portions of Townships 23, to 25, Ranges 1 to 3, W4M. The project is comprised of a number of segments. An intake and pumping station will be situated along the Red Deer River in 5-23-3-W4M. From the intake, a pipeline will be used to get the water to a man made reservoir associated with an unnamed tributary of Kennedy's Coulee. The downstream dam is proposed for the eastern side of 20-23-3-W4M while the upstream end is proposed for the western edge of 19-23-3-W4M. The proposed reservoir will be close to three kilometres in length and as much as half a kilometre or more in width at its widest.

Irrigation development in the area will focus on a number of blocks (1A, 1B, 2, 3 and 4) and with minor exceptions, the lands are presently cultivated. Three scenarios are proposed for the development. Scenario 1 includes Blocks 1A, 1B and 4, scenario 2 includes Blocks 1A, 1B, 2 and 4 while the third scenario in includes Blocks 1A, 1B, 2, 3 and 4.Block 1A is north and east of the east dam and north of the drainage. It will encompass all or portions of sections 26 to 28 and 33 to 36-23-3-W4M, sections 1 to 3, 11 to 14, 24 and 25-24-3-W4M, section 31-23-2-W4M and sections 6, 7, 18, 19 29 and 30-24-2-W4M. Block 1B is south and east of the reservoir and will include all or portions of sections 19 and 20, 28 and 29-23-2-W4M and sections 15, 16 and 21 to 27-23-3-W4M.

Block 2 is east of the north south oriented Kennedy's Coulee and includes all or portions of section 31-23-1-W4M, sections 34 to 36-23-2-W4M, sections 6 and 7-24-1-W4M and sections 1 to 4, 9 to 12, 14 to 17, 20 to 22 and 28-24-2-W4M. Block 3 is immediately north of Block 2 and includes all or portions of section 7 and 17 to 20-24-1-W4M along with sections 12 to 14 and 22 to 24-24-2-W4M.

Finally, Block 4 is the northern most block and straddles Kennedy Creek. It includes all or portions of section 27, 31 and 32-24-2-W4M and sections 5 to 9-25-2-W4M. This block encompasses an existing man-made reservoir along Kennedy's Coulee.

As proposed, a pipeline will provide water to Block 1B from the main dam. A secondary canal will provide water to Block 1A with a tie-in into the existing dam on Kennedy's Coulee in Block 4. Block 2 will be provided with water by means of a secondary canal that will tie into the secondary canal in Block 1A. It will cross Kennedy's Coulee by means of siphon along the south side of sections 28 and 29-24-2-W4M. Water to Block 3

Project Name Irrigation Development HRO - M.D. of Acadia #34

HRO 05-018

Evaluation cont: is proposed to flow along a secondary canal from the existing reservoir on Kennedy's Coulee.

As outlined previously all or most of the lands under consideration for irrigation are presently cultivated. The canals and pipelines will largely be associated with agricultural lands that are disturbed and as such are of limited concern. However, such is not the case for individual portions of this development.

Major areas associated with undisturbed lands will include the proposed intake and pipeline to the reservoir, the reservoir itself, the siphon across Kennedy's Coulee and other small portions of the project. It is these areas that have the greatest potential to impact previously undisturbed cultural resources.

As outlined on the attached maps, the proposed project is associated with six Borden Blocks: EfOm, EfOn, EfOo, EgOm, EgOn and EgOo. A large number of sites are presently known in the area but very few are directly associated with areas that might be impacted. The sites are largely associated with terrain that parallels the Red Deer River or Kennedy's Coulee and its tributary. The HRV notations in the area include 4 and 5 for both archaeology and palaeontology.

Many sites are close to the proposed projects but of particular concern are those close to the intake on the Red Deer, those associated with the proposed reservoir and those close to the siphon on Kennedy's Coulee. EfOo 93 and 116 (both stone cairns) appear to be close to the proposed intake. EfOo 54 to 57, 94 and 95 are along the upper edges of the unnamed tributary and adjacent to the proposed reservoir. These sites are also all stone features including stone circles, cairns and stone alignment. EgOn 14 is a stone circle site along Kennedy's Coulee in the vicinity of the proposed siphon.

Project Name Irrigation Development HRO - M.D. of Acadia #34

HRO 05-018

Recommendations This project is associated with a variety of landforms along with both disturbed and undisturbed terrains. Various sections within the development area have archaeological and palaeontological notations for both known and potential resources. The archaeological potential of undisturbed areas is very high while the palaeontological potential is highest along the Red Deer River, Kennedy's Coulee and the unnamed tributary that is proposed as the reservoir site. The tributary is a minor meltwater channel. The potential exists for buried resources within the unnamed tributary along the Red Deer River and at the crossing of Kennedy's Coulee.

A Historical Resources Impact Assessment is recommended for this project. This work is recommended for undisturbed areas including the intake, intake pipeline, reservoir, and the distribution canals and pipelines. Deep testing is recommended for this project with a particular focus on depositional areas including but not limited to the water intake on the Red Deer River, the proposed reservoir and the siphon crossing of Kennedy's Coulee.

Portions of the project are associated with sections with paleontological notations and paleontology will also require consideration.

- [ ] An HRIA is **not** recommended; however, pursuant to Section 31 of the Historical Resources Act, should historic resources be discovered during construction the HRMB is to be contacted immediately.
- [ ] A predevelopment HRIA is **not** recommended,however a monitoring or post-impact assessment program is recommended.
- [X] Pursuant to Section 37(2) of the Historical Resources Act, **an HRIA is recommended**.

Signature __________ Date February 24th, 2005

Government Use Only

HSAB __________ Date __________

Approved __________ Date __________

Regional Archaeologist

Approved __________ Date __________

Head, Archaeological Survey

Approved __________ Date __________

Manager, Archaeology and History

Heritage Resource Management (Provincial Archaeologist)

Study of Irrigation Development in the M.D. of Acadia #34
HRO 05-018
Bison# 502-134

SCENARIO 1

<u>Study Area</u>
Twp 23, Rge 3 W4M
1-23-3-W4M HRV=N/A
2-23-3-W4M HRV=N/A
3-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor
4-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor
5-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor
6-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
7-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
8-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
9-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
10-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
11-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
12-23-3-W4M HRV=N/A
13-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
14-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
15-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
16-23-3-W4M HRV=N/A
17-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
18-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
19-23-3-W4M HRV=5(A) Miner #3 Medicine Wheel EfOo-24
20-23-3-W4M HRV=N/A
21-23-3-W4M HRV=N/A
22-23-3-W4M HRV=N/A
23-23-3-W4M HRV=N/A
24-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
25-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
26-23-3-W4M HRV=N/A
27-23-3-W4M HRV=N/A
28-23-3-W4M HRV=N/A
29-23-3-W4M HRV=N/A
30-23-3-W4M HRV=N/A
31-23-3-W4M HRV=N/A
32-23-3-W4M HRV=N/A
33-23-3-W4M HRV=N/A
34-23-3-W4M HRV=N/A

35-23-3-W4M HRV=N/A
36-23-3-W4M HRV=N/A

Twp 24, Rge 3 W4M
1-24-3-W4M HRV=N/A
2-24-3-W4M HRV=N/A
3-24-3-W4M HRV=N/A
4-24-3-W4M HRV=N/A
9-24-3-W4M HRV=N/A
10-24-3-W4M HRV=N/A
11-24-3-W4M HRV=N/A
12-24-3-W4M HRV=N/A
13-24-3-W4M HRV=N/A
14-24-3-W4M HRV=N/A
24-24-3-W4M HRV=N/A
25-24-3-W4M HRV=N/A

Twp 23, Rge 2 W4M
5-23-2-W4M HRV=N/A
6-23-2-W4M HRV=N/A
7-23-2-W4M HRV=4 (A) campsite EfOm-37
8-23-2-W4M HRV=N/A
9-23-2-W4M HRV=N/A
10-23-2-W4M HRV=4 (A) campsite/stone circle/cairn EfOn-23; HRV=5 (P) 'high' palaeontological resource sensitivity zone
11-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
12-23-2-W4M HRV=5 (P) Bindloss palaeontological site; HRV=4 (A) campsite EfOm-37
13-23-2-W4M HRV=4 (A) cairn EfOm-61; HRV=5 (P) 'high' palaeontological resource sensitivity zone
14-23-2-W4M HRV=4 (A) cairn EfOn-141; HRV=5 (P) 'high' palaeontological resource sensitivity zone
15-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
16-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
17-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
18-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
19-23-2-W4M HRV=N/A
20-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
21-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
22-23-2-W4M HRV=N/A
23-23-2-W4M HRV=N/A
24-23-2-W4M HRV=N/A
25-23-2-W4M HRV=N/A
26-23-2-W4M HRV=N/A
27-23-2-W4M HRV=N/A
28-23-2-W4M HRV=N/A
29-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
30-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
31-23-2-W4M HRV=N/A
32-23-2-W4M HRV=N/A
33-23-2-W4M HRV=N/A

34-23-2-W4M HRV=N/A
35-23-2-W4M HRV=N/A
36-23-2-W4M HRV=N/A

Twp 24, Rge 2 W4M
1-24-2-W4M HRV=N/A
2-24-2-W4M HRV=N/A
3-24-2-W4M HRV=N/A
4-24-2-W4M HRV=N/A
5-24-2-W4M HRV=N/A
6-24-2-W4M HRV=N/A
7-24-2-W4M HRV=N/A
8-24-2-W4M HRV=N/A
9-24-2-W4M HRV=N/A
10-24-2-W4M HRV=N/A
11-24-2-W4M HRV=N/A
12-24-2-W4M HRV=N/A
13-24-2-W4M HRV=N/A
14-24-2-W4M HRV=N/A
15-24-2-W4M HRV=N/A
16-24-2-W4M HRV=N/A
17-24-2-W4M HRV=4 (A) scatter EgOn-21; stone circle/cairn EgOn-18
18-24-2-W4M HRV=N/A
19-24-2-W4M HRV=N/A
20-24-2-W4M HRV=N/A
21-24-2-W4M HRV=N/A
22-24-2-W4M HRV=N/A
23-24-2-W4M HRV=N/A
24-24-2-W4M HRV=N/A
28-24-2-W4M HRV=N/A
29-24-2-W4M HRV=N/A
30-24-2-W4M HRV=N/A
31-24-2-W4M HRV=N/A
32-24-2-W4M HRV=N/A
33-24-2-W4M HRV=N/A

Twp 25, Rge 2 W4M
4-25-2-W4M HRV=N/A
5-25-2-W4M HRV=N/A
6-25-2-W4M HRV=N/A
7-25-2-W4M HRV=N/A
8-25-2-W4M HRV=N/A
9-25-2-W4M HRV=N/A

Twp 23, Rge 1 W4M
7-23-1-W4M HRV=5 (P) Red Deer River Corridor
8-23-1-W4M HRV=5 (P) Red Deer River Corridor
17-23-1-W4M HRV=N/A
18-23-1-W4M HRV=N/A
19-23-1-W4M HRV=N/A

20-23-1-W4M HRV=N/A
21-23-1-W4M HRV=N/A
22-23-1-W4M HRV=5 (P) Red Deer River Corridor
27-23-1-W4M HRV=N/A
28-23-1-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
29-23-1-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone
30-23-1-W4M HRV=N/A
31-23-1-W4M HRV=N/A
32-23-1-W4M HRV=N/A

Twp 24, Rge 1 W4M
6-24-1-W4M HRV=N/A
7-24-1-W4M HRV=N/A
15-24-1-W4M HRV=N/A
16-24-1-W4M HRV=N/A
17-24-1-W4M HRV=N/A
18-24-1-W4M HRV=N/A
19-24-1-W4M HRV=N/A
20-24-1-W4M HRV=N/A
21-24-1-W4M HRV=N/A
22-24-1-W4M HRV=N/A

Pipeline
Twp 23, Rge 3 W4M
NW1/4-5-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor
SE1/4-8-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone & Red Deer River Corridor; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
SW1/4-9-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
NW1/4-9-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
SW1/4-16-23-3-W4M HRV=N/A
NE1/4-17-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
SE1/4-17-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone; HRV=5(A) Miner #3 Medicine Wheel EfOo-24
SE1/4-20-23-3-W4M HRV=N/A
NE1/4-20-23-3-W4M HRV=N/A
NW1/4-21-23-3-W4M HRV=N/A
SW1/4-21-23-3-W4M HRV=N/A
SE1/4-21-23-3-W4M HRV=N/A
NW1/4-22-23-3-W4M HRV=N/A
NE1/4-22-23-3-W4M HRV=N/A
NW1/4-23-23-3-W4M HRV=N/A
NE1/4-23-23-3-W4M HRV=N/A
NW1/4-24-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
NE1/4-24-23-3-W4M HRV=5(P) 'high' palaeontological resource sensitivity zone
NW1/4-27-23-3-W4M HRV=N/A
SW1/4-28-23-3-W4M HRV=N/A
SE1/4-28-23-3-W4M HRV=N/A
NE1/4-28-23-3-W4M HRV=N/A

SW1/4-34-23-3-W4M HRV=N/A
NW1/4-34-23-3-W4M HRV=N/A
NE1/4-34-23-3-W4M HRV=N/A

Twp 24, Rge 3 W4M
SW1/4-2-24-3-W4M HRV=N/A
NW1/4-2-24-3-W4M HRV=N/A
NE1/4-2-24-3-W4M HRV=N/A
SE1/4-3-24-3-W4M HRV=N/A
SE1/4-11-24-3-W4M HRV=N/A
NE1/4-11-24-3-W4M HRV=N/A
NW1/4-12-24-3-W4M HRV=N/A
SW1/4-13-24-3-W4M HRV=N/A
NW1/4-13-24-3-W4M HRV=N/A
NE1/4-13-24-3-W4M HRV=N/A
SE1/4-24-24-3-W4M HRV=N/A

Twp 23, Rge 2 W4M
NW1/4-19-23-2-W4M HRV=N/A
NE1/4-19-23-2-W4M HRV=N/A
SE1/4-30-23-2-W4M HRV=5 (P) 'high' palaeontological resource sensitivity zone

Twp 25, Rge 2 W4M
SW1/4-5-25-2-W4M HRV=N/A
SW1/4-6-25-2-W4M HRV=N/A
SE1/4-6-25-2-W4M HRV=N/A

<u>Irrigation Blocks</u>
Twp 23, Rge 3 W4M
N1/2-15-23-3-W4M (BLOCK 1B) HRV=5(P) 'high' palaeontological resource sensitivity zone
N1/2-16-23-3-W4M (BLOCK 1B) HRV=N/A
S1/2-21-23-3-W4M (BLOCK 1B) HRV=N/A
S1/2-22-23-3-W4M (BLOCK 1B) HRV=N/A
N1/2-22-23-3-W4M (BLOCK 1B) HRV=N/A
S1/2-23-23-3-W4M (BLOCK 1B) HRV=N/A
N1/2-23-23-3-W4M (BLOCK 1B) HRV=N/A
S1/2-24-23-3-W4M (BLOCK 1B) HRV=5(P) 'high' palaeontological resource sensitivity zone
N1/2-24-23-3-W4M (BLOCK 1B) HRV=5(P) 'high' palaeontological resource sensitivity zone
S1/2-25-23-3-W4M (BLOCK 1B) HRV=5(P) 'high' palaeontological resource sensitivity zone
S1/2-26-23-3-W4M (BLOCK 1B) HRV=N/A
N1/2-26-23-3-W4M (BLOCK 1B) HRV=N/A
SW1/4-27-23-3-W4M (BLOCK 1B) HRV=N/A
N1/2-27-23-3-W4M (BLOCK 1A) HRV=N/A
SE1/4-27-23-3-W4M (BLOCK 1A) HRV=N/A
S1/2-28-23-3-W4M (BLOCK 1A) HRV=N/A

N1/2-28-23-3-W4M (BLOCK 1A) HRV=N/A
E1/2-33-23-3-W4M (BLOCK 1A) HRV=N/A
S1/2-34-23-3-W4M (BLOCK 1A) HRV=N/A
N1/2-34-23-3-W4M (BLOCK 1A) HRV=N/A
S1/2-35-23-3-W4M (BLOCK 1A) HRV=N/A
N1/2-35-23-3-W4M (BLOCK 1A) HRV=N/A
S1/2-36-23-3-W4M (BLOCK 1A) HRV=N/A
N1/2-36-23-3-W4M (BLOCK 1A) HRV=N/A

Twp 24, Rge 3 W4M
S1/2-1-24-3-W4M (BLOCK 1A) HRV=N/A
N1/2-1-24-3-W4M (BLOCK 1A) HRV=N/A
S1/2-2-24-3-W4M (BLOCK 1A) HRV=N/A
N1/2-2-24-3-W4M (BLOCK 1A) HRV=N/A
S1/2-3-24-3-W4M (BLOCK 1A) HRV=N/A
E1/2-11-24-3-W4M (BLOCK 1A) HRV=N/A
S1/2-12-24-3-W4M (BLOCK 1A) HRV=N/A
N1/2-12-24-3-W4M (BLOCK 1A) HRV=N/A
S1/2-13-24-3-W4M (BLOCK 1A) HRV=N/A
N1/2-13-24-3-W4M (BLOCK 1A) HRV=N/A
SE1/4-14-24-3-W4M (BLOCK 1A) HRV=N/A
S1/2-24-24-3-W4M (BLOCK 1A) HRV=N/A
N1/2-24-24-3-W4M (BLOCK 1A) HRV=N/A
E1/2-25-24-3-W4M (BLOCK 1A) HRV=N/A

Twp 23, Rge 2 W4M
S1/2-19-23-2-W4M (BLOCK 1B) HRV=N/A
N1/2-19-23-2-W4M (BLOCK 1B) HRV=N/A
W1/2-20-23-2-W4M (BLOCK 1B) HRV=5 (P) ‘high’ palaeontological resource sensitivity zone
SW1/4-29-23-2-W4M (BLOCK 1B) HRV=5 (P) ‘high’ palaeontological resource sensitivity zone
S1/2-30-23-2-W4M (BLOCK 1B) HRV=5 (P) ‘high’ palaeontological resource sensitivity zone
N1/2-31-23-2-W4M (BLOCK 1A) HRV=N/A
SW1/4-31-23-2-W4M (BLOCK 1A) HRV=N/A

Twp 24, Rge 2 W4M
S1/2-6-24-2-W4M (BLOCK 1A) HRV=N/A
N1/2-6-24-2-W4M (BLOCK 1A) HRV=N/A
S1/2-7-24-2-W4M (BLOCK 1A) HRV=N/A
N1/2-7-24-2-W4M (BLOCK 1A) HRV=N/A
S1/2-18-24-2-W4M (BLOCK 1A) HRV=N/A
N1/2-18-24-2-W4M (BLOCK 1A) HRV=N/A
S1/2-28-24-2-W4M (BLOCK 4) HRV=N/A
N1/2-28-24-2-W4M (BLOCK 4) HRV=N/A
S1/2-30-24-2-W4M (BLOCK 1A) HRV=N/A
N1/2-30-24-2-W4M (BLOCK 1A) HRV=N/A
S1/2-31-24-2-W4M (BLOCK 1A) HRV=N/A
N1/2-31-24-2-W4M (BLOCK 1A) HRV=N/A

S1/2-32-24-2-W4M (BLOCK 4) HRV=N/A
N1/2-32-24-2-W4M (BLOCK 4) HRV=N/A
S1/2-33-24-2-W4M (BLOCK 4) HRV=N/A

Twp 25, Rge 2 W4M
S1/2-5-25-2-W4M (BLOCK 4) HRV=N/A
N1/2-5-25-2-W4M (BLOCK 4) HRV=N/A
S1/2-6-25-2-W4M (BLOCK 4) HRV=N/A
N1/2-6-25-2-W4M (BLOCK 4) HRV=N/A
S1/2-7-25-2-W4M (BLOCK 4) HRV=N/A
NE1/4-7-25-2-W4M (BLOCK 4) HRV=N/A
S1/2-8-25-2-W4M (BLOCK 4) HRV=N/A
N1/2-8-25-2-W4M (BLOCK 4) HRV=N/A
SW1/4-9-25-2-W4M (BLOCK 4) HRV=N/A

SCENARIO 2 (The legals are the same as in Scenario 1 with the addition of the following:)

Pipeline
Twp 24, Rge 2 W4M
NE1/4-1-24-2-W4M HRV=N/A
NW1/4-1-24-2-W4M HRV=N/A
SE1/4-11-24-2-W4M HRV=N/A
SW1/4-11-24-2-W4M HRV=N/A
NW1/4-11-24-2-W4M HRV=N/A
SE1/4-12-24-2-W4M HRV=N/A
SW1/4-12-24-2-W4M HRV=N/A
SE1/4-15-24-2-W4M HRV=N/A
SW1/4-15-24-2-W4M HRV=N/A
NW1/4-15-24-2-W4M HRV=N/A
NE1/4-16-24-2-W4M HRV=N/A
NW1/4-16-24-2-W4M HRV=N/A
NW1/4-19-24-2-W4M HRV=N/A
NE1/4-19-24-2-W4M HRV=N/A
NE1/4-20-24-2-W4M HRV=N/A
NW1/4-20-24-2-W4M HRV=N/A
NW1/4-21-24-2-W4M HRV=N/A
SW1/4-21-24-2-W4M HRV=N/A
SE1/4-29-24-2-W4M HRV=N/A
SW1/4-29-24-2-W4M HRV=N/A
NW1/4-30-24-2-W4M HRV=N/A
NE1/4-30-24-2-W4M HRV=N/A
SW1/4-30-24-2-W4M HRV=N/A
SE1/4-30-24-2-W4M HRV=N/A
NW1/4-31-24-2-W4M HRV=N/A
NE1/4-31-24-2-W4M HRV=N/A
SW1/4-31-24-2-W4M HRV=N/A
SE1/4-31-24-2-W4M HRV=N/A

Twp 24, Rge 1 W4M
NW1/4-6-24-1-W4M HRV=N/A
SW1/4-7-24-1-W4M HRV=N/A

Irrigation Blocks
Twp 23, Rge 2 W4M
E1/2-33-23-2-W4M (BLOCK 2) HRV=N/A
S1/2-34-23-2-W4M (BLOCK 2) HRV=N/A
N1/2-34-23-2-W4M (BLOCK 2) HRV=N/A
S1/2-35-23-2-W4M (BLOCK 2) HRV=N/A
N1/2-35-23-2-W4M (BLOCK 2) HRV=N/A
S1/2-36-23-2-W4M (BLOCK 2) HRV=N/A
N1/2-36-23-2-W4M (BLOCK 2) HRV=N/A

Twp 24, Rge 2 W4M
S1/2-1-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-1-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-2-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-2-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-3-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-3-24-2-W4M (BLOCK 2) HRV=N/A
SE1/4-4-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-4-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-9-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-9-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-10-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-10-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-11-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-11-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-12-24-2-W4M (BLOCK 2) HRV=N/A
NW1/4-12-24-2-W4M (BLOCK 2) HRV=N/A
SW1/4-14-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-15-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-15-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-16-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-16-24-2-W4M (BLOCK 2) HRV=N/A
E1/2-17-24-2-W4M (BLOCK 2) HRV=4 (A) scatter EgOn-21; stone circle/cairn EgOn-18
E1/2-20-24-2-W4M (BLOCK 2) HRV=N/A
S1/2-21-24-2-W4M (BLOCK 2) HRV=N/A
N1/2-21-24-2-W4M (BLOCK 2) HRV=N/A
SW1/4-22-24-2-W4M (BLOCK 2) HRV=N/A
SW1/4-29-24-2-W4M (BLOCK 2) HRV=N/A

Twp 25, Rge 1 W4M
SW1/4 -31-25-1-W4M (BLOCK 2) HRV=N/A
N1/2-31-25-1-W4M (BLOCK 2) HRV=N/A

Twp 24, Rge 1 W4M
S1/2 -6-24-1-W4M (BLOCK 2) HRV=N/A
N1/2-6-24-1-W4M (BLOCK 2) HRV=N/A

S1/2 -7-24-1-W4M (BLOCK 2) HRV=N/A

<u>SCENARIO 3 (The legals are the same as in Scenario 1&2 with the addition of the following:)</u>

<u>Pipeline</u>

TWP 25, RGE 2 W4M

SW1/4-5-25-2-W4M HRV=N/A
SE1/4-5-25-2-W4M HRV=N/A

TWP 24, RGE 2 W4M

NW1/4-21-24-2-W4M HRV=N/A
NE1/4-21-24-2-W4M HRV=N/A
SE1/4-21-24-2-W4M HRV=N/A
NW1/4-22-24-2-W4M HRV=N/A
NE1/4-22-24-2-W4M HRV=N/A
SW1/4-2-24-2-W4M HRV=N/A
SE1/4-22-24-2-W4M HRV=N/A
NW1/4-23-24-2-W4M HRV=N/A
NE1/4-23-24-2-W4M HRV=N/A
SW1/4-23-24-2-W4M HRV=N/A
SE1/4-23-24-2-W4M HRV=N/A
NW1/4-24-24-2-W4M HRV=N/A
NE1/4-24-24-2-W4M HRV=N/A
SW1/4-24-24-2-W4M HRV=N/A
SE1/4-24-24-2-W4M HRV=N/A

TWP 24, RGE 1 W4M

NW1/4-19-24-1-W4M HRV=N/A
NE1/4-19-24-1-W4M HRV=N/A
SW1/4-19-24-1-W4M HRV=N/A
SE1/4-19-24-1-W4M HRV=N/A
NW1/4-20-24-1-W4M HRV=N/A
SW1/4-20-24-1-W4M HRV=N/A

<u>Irrigation Blocks</u>

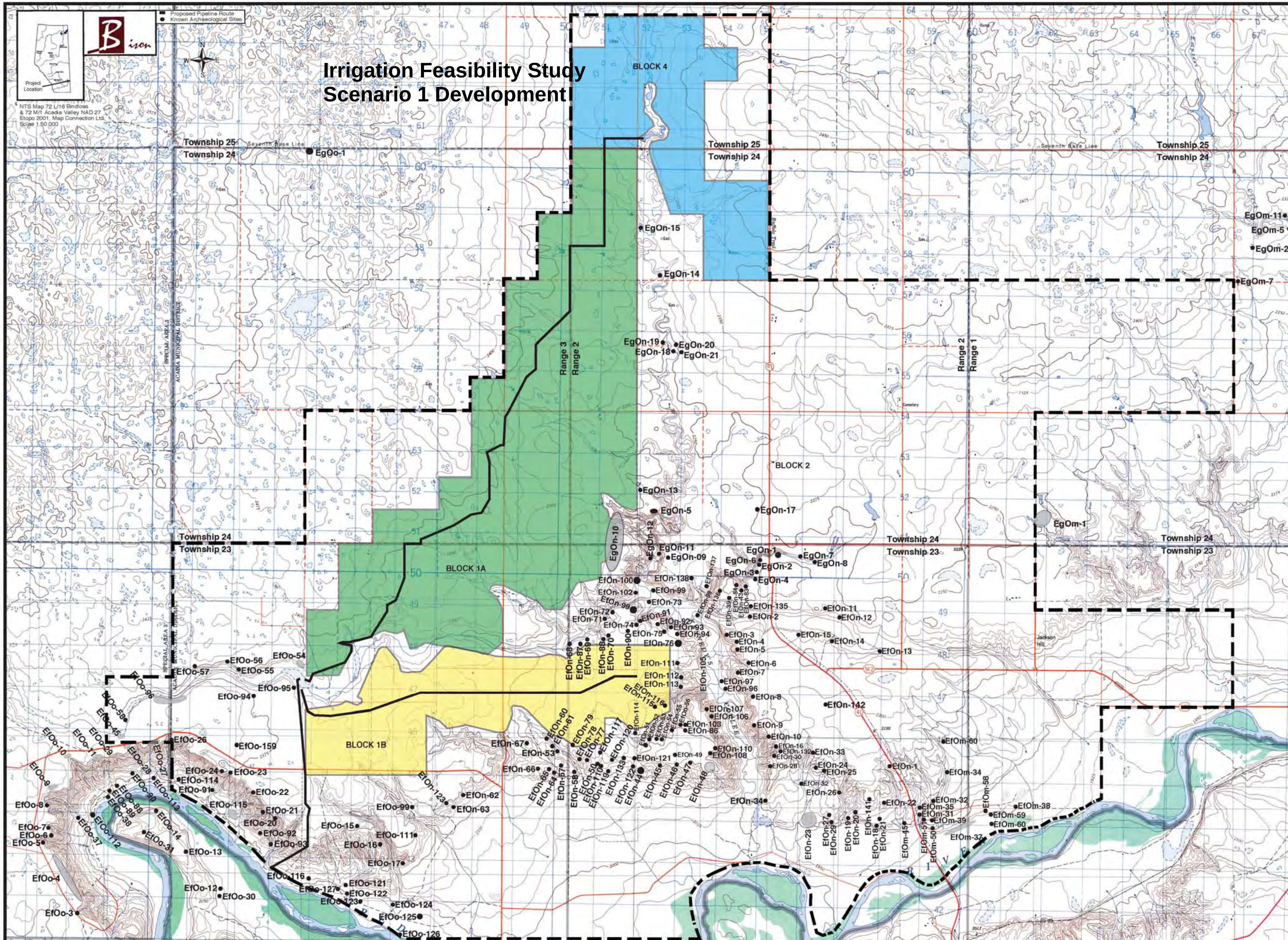
TWP 24, RGE 2 W4M

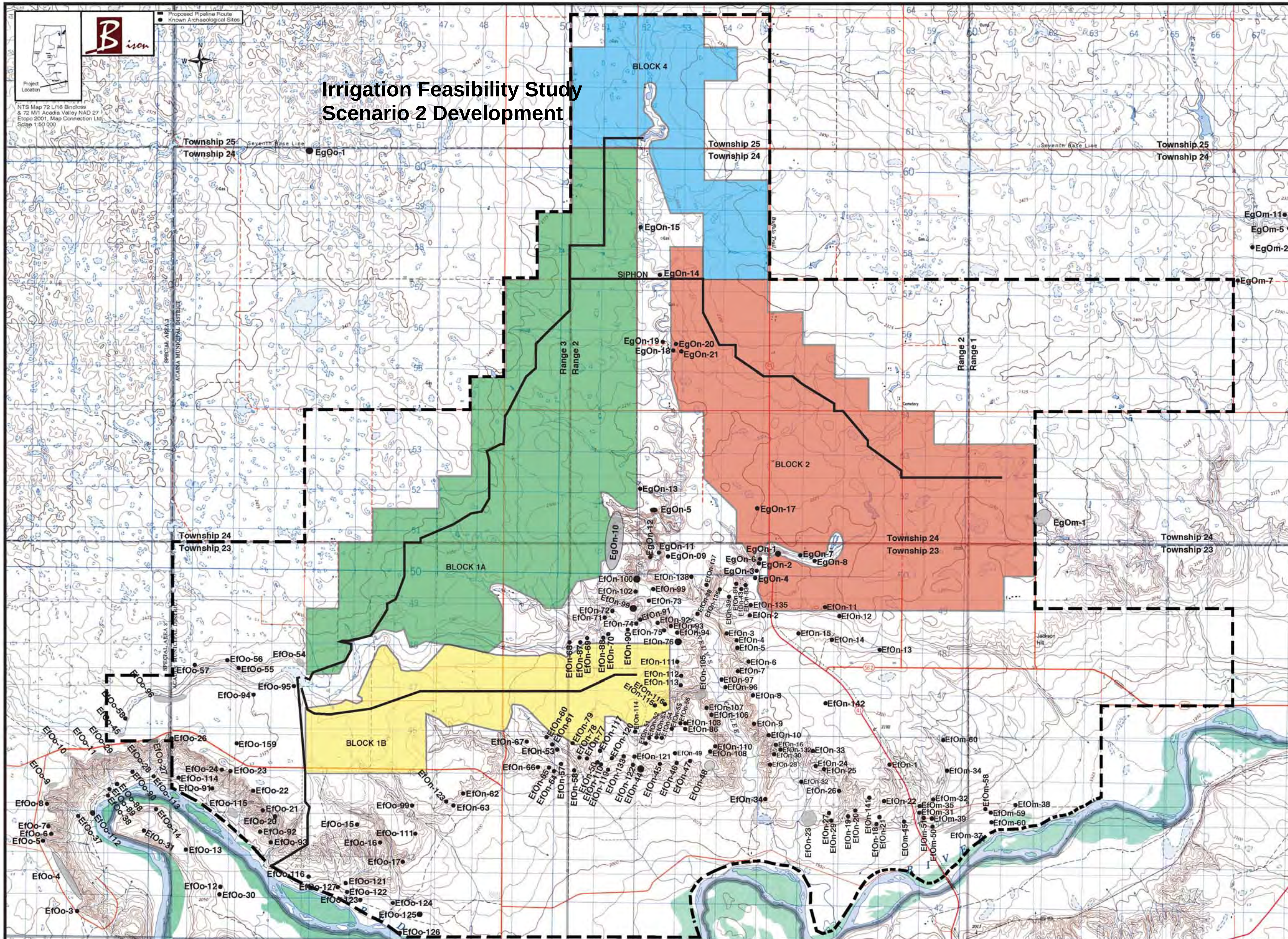
SE1/4-12-24-2-W4M (BLOCK 3) HRV=N/A
S1/2-13-24-2-W4M (BLOCK 3) HRV=N/A
N1/2-13-24-2-W4M (BLOCK 3) HRV=N/A
SE1/4-14-24-2-W4M (BLOCK 3) HRV=N/A
N1/2-14-24-2-W4M (BLOCK 3) HRV=N/A
SE1/4-22-24-2-W4M (BLOCK 3) HRV=N/A
N1/2-22-24-2-W4M (BLOCK 3) HRV=N/A
S1/2-23-24-2-W4M (BLOCK 3) HRV=N/A
N1/2-23-24-2-W4M (BLOCK 3) HRV=N/A
S1/2-24-24-2-W4M (BLOCK 3) HRV=N/A
N1/2-24-24-2-W4M (BLOCK 3) HRV=N/A

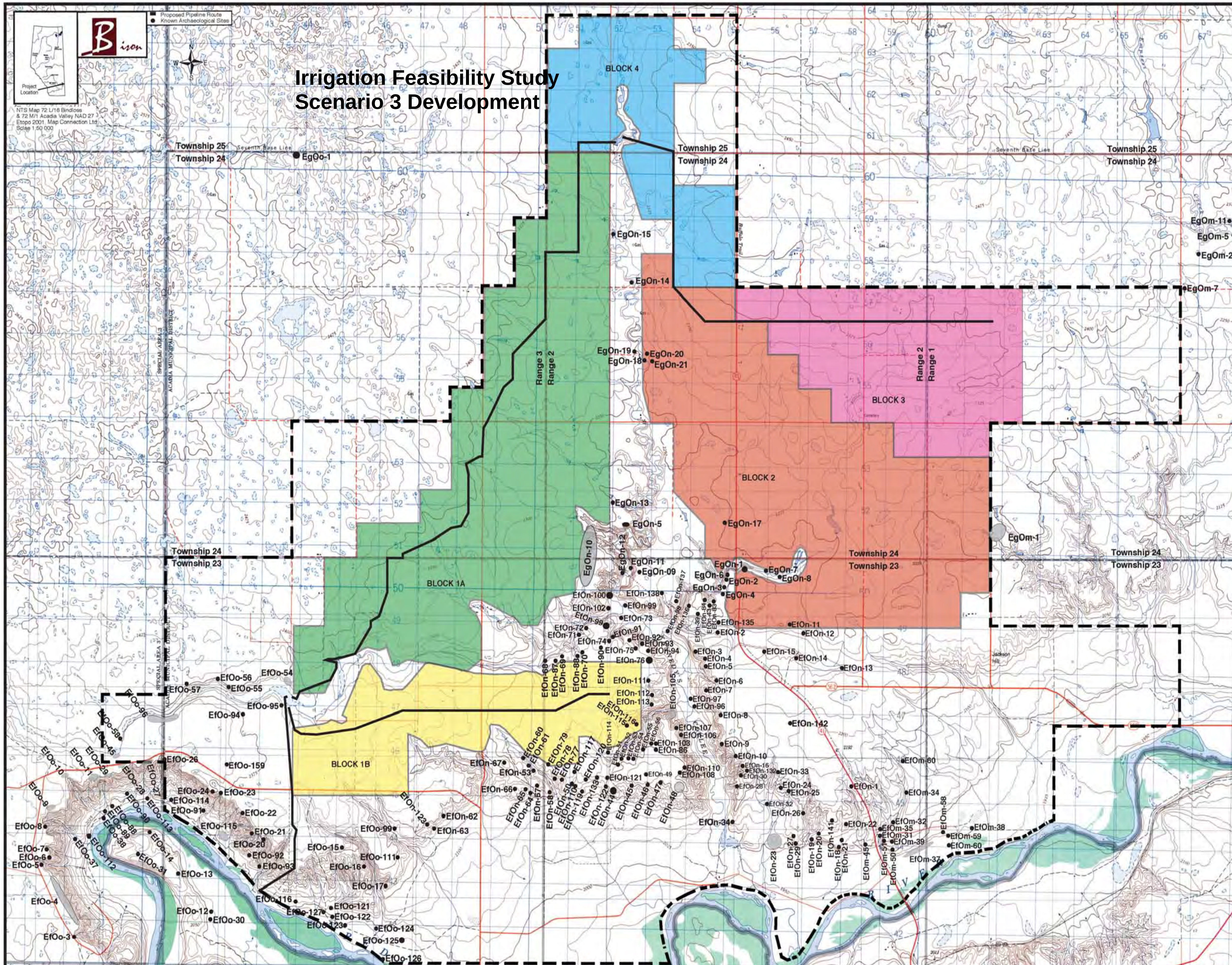
TWP 24, RGE 1 W4M

E1/2-17-24-1-W4M (BLOCK 3) HRV=N/A
S1/2-18-24-1-W4M (BLOCK 3) HRV=N/A
N1/2-18-24-1-W4M (BLOCK 3) HRV=N/A

S1/2-19-24-1-W4M (BLOCK 3) HRV=N/A
N1/2-19-24-1-W4M (BLOCK 3) HRV=N/A
E1/2-20-24-1-W4M (BLOCK 3) HRV=N/A


Irrigation Feasibility Study
Scenario 1 Development
Proposed Pipeline Route
Known Archaeological Sites
Project Location
NTS Map 72 L/16 Bindloss & 72 M/1 Acadia Valley NAD 27
Etopo 2001, Map Connection Ltd.
Scale 1:50,000
BLOCK 4
BLOCK 1A
BLOCK 1B
BLOCK 2
Township 25
Township 24
Township 23
Range 3
Range 2
Range 1
Seventh Base Line
EgOo-1
EgOn-15
EgOn-14
EgOn-19
EgOn-18
EgOn-20
EgOn-21
EgOn-13
EgOn-5
EgOn-17
EgOn-10
EgOn-12
EgOn-11
EgOn-09
EgOn-1
EgOn-6
EgOn-2
EgOn-3
EgOn-4
EgOn-7
EgOn-8
EgOm-11
EgOm-5
EgOm-2
EgOm-7
EgOm-1
EfOn-100
EfOn-138
EfOn-102
EfOn-99
EfOn-73
EfOn-72
EfOn-71
EfOn-74
EfOn-75
EfOn-76
EfOn-91
EfOn-92
EfOn-93
EfOn-94
EfOn-135
EfOn-2
EfOn-3
EfOn-4
EfOn-5
EfOn-6
EfOn-7
EfOn-8
EfOn-9
EfOn-10
EfOn-11
EfOn-12
EfOn-13
EfOn-14
EfOn-15
EfOn-142
EfOn-111
EfOn-112
EfOn-113
EfOn-97
EfOn-96
EfOn-107
EfOn-106
EfOn-103
EfOn-86
EfOn-110
EfOn-108
EfOn-121
EfOn-49
EfOn-67
EfOn-53
EfOn-66
EfOn-34
EfOn-33
EfOn-24
EfOn-25
EfOn-26
EfOn-22
EfOn-1
EfOn-23
EfOm-60
EfOm-34
EfOm-32
EfOm-35
EfOm-31
EfOm-39
EfOm-38
EfOm-59
EfOm-37
EfOo-54
EfOo-56
EfOo-55
EfOo-57
EfOo-95
EfOo-94
EfOo-96
EfOo-26
EfOo-159
EfOo-24
EfOo-114
EfOo-91
EfOo-23
EfOo-22
EfOo-115
EfOo-21
EfOo-20
EfOo-92
EfOo-93
EfOo-13
EfOo-8
EfOo-7
EfOo-6
EfOo-5
EfOo-4
EfOo-3
EfOo-12
EfOo-30
EfOo-116
EfOo-127
EfOo-121
EfOo-122
EfOo-123
EfOo-124
EfOo-125
EfOo-126
EfOo-15
EfOo-16
EfOo-17
EfOo-111
EfOo-99
EfOo-62
EfOo-63
EfOo-123
Jackson Hill


Irrigation Feasibility Study
Scenario 2 Development
Proposed Pipeline Route
Known Archaeological Sites
Project Location
NTS Map 72 L/16 Bindloss & 72 M/1 Acadia Valley NAD 27
Etopo 2001, Map Connection Ltd.
Scale 1:50 000
BLOCK 4
BLOCK 2
BLOCK 1A
BLOCK 1B
SIPHON
Township 25
Township 24
Township 23
Range 3
Range 2
Range 1
Seventh Base Line
EgOo-1
EgOn-15
EgOn-14
EgOn-13
EgOn-5
EgOn-17
EgOm-1
EgOm-11
EgOm-5
EgOm-2
EgOm-7
EfOo-54
EfOo-56
EfOo-57
EfOo-95
EfOo-94
EfOo-26
EfOo-159
EfOo-13
EfOo-30
EfOo-126
EfOn-142
EfOm-60


Irrigation Feasibility Study
Scenario 3 Development
Proposed Pipeline Route
Known Archaeological Sites
Project Location
NTS Map 72 L/16 Bindloss & 72 M/1 Acadia Valley NAD 27
Etopo 2001, Map Connection Ltd.
Scale 1:50 000
BLOCK 4
BLOCK 3
BLOCK 2
BLOCK 1A
BLOCK 1B
Township 25
Township 24
Township 23
Range 3
Range 2
Range 1

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-1		scatter		HRV 4	ASA 75-004
EfOn-2		stone feature	cairn	HRV 4	ASA 75-004
EfOn-3		scatter; stone feature	cairn	HRV 4	ASA 75-004
EfOn-4		scatter; stone feature	cairn	HRV 4	ASA 75-004
EfOn-5		campsite; stone feature	stone circle	HRV 4	ASA 75-004
EfOn-6		campsite		HRV 4	ASA 75-004
EfOn-7		campsite; stone feature	stone circle (double)	HRV 4	ASA 75-004
EfOn-8		campsite		HRV 4	ASA 75-004
EfOn-9		campsite		HRV 4	ASA 75-004
EfOn-10		campsite; stone feature	cairn	HRV 4	ASA 75-004
EfOn-11		stone feature	cairn	HRV 4	ASA 75-004
EfOn-12		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOn-13		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-14		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-15		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-16		stone feature	cairn	HRV 4	ASA 75-004
EfOn-17		campsite		HRV 4	ASA 75-004
EfOn-18		campsite		HRV 4	ASA 75-004
EfOn-19		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOn-20		stone feature	stone circle	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-21		scatter		HRV 0	ASA 75-004
EfOn-22		stone feature	cairn	HRV 4	ASA 75-004
EfOn-23		campsite; stone feature; ceremonial	stone circle; cairn; medicine wheel ?	HRV 4	ASA 75-004; ASA 76-035; ASA CRM 090
EfOn-24		stone feature	cairn	HRV 4	ASA 75-004
EfOn-25		stone feature	cairn	HRV 4	ASA 75-004
EfOn-26		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-27		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-28		stone feature	cairn; drive lane	HRV 4	ASA 75-004
EfOn-29		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOn-30		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-31		stone feature	cairn	HRV 4	ASA 75-004
EfOn-32		campsite		HRV 0	ASA 75-004
EfOn-33		campsite		HRV 0	ASA 75-004
EfOn-34		scatter		HRV 4	ASA 75-004
EfOn-35		stone feature	cairn	HRV 4	ASA 75-004
EfOn-36		campsite		HRV 4	ASA 75-004
EfOn-37		campsite		HRV 0	ASA 75-004
EfOn-38		campsite		HRV 4	ASA 75-004
EfOn-39		stone feature	cairn; drive lane	HRV 4	ASA 75-004
EfOn-40		campsite		HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-41		campsite; collection		HRV 0	ASA 75-004
EfOn-42		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-43		stone feature	cairn	HRV 4	ASA 75-004
EfOn-44		stone feature	cairn	HRV 4	ASA 75-004
EfOn-45		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-46		scatter		HRV 0	ASA 75-004
EfOn-47		scatter		HRV 0	ASA 75-004
EfOn-48		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-49		scatter		HRV 0	ASA 75-004
EfOn-50		stone feature; natural	stone circle; cairn; rubbing stone; alignment	HRV 4	ASA 75-004
EfOn-51		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-52		stone feature	cairn; drive lane; alignment	HRV 4	ASA 75-004
EfOn-53		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-54		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-55		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-56		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-57		stone feature	cairn	HRV 4	ASA 75-004
EfOn-58		stone feature; homestead; natural	cairn; rubbing stone	HRV 4	ASA 75-004
EfOn-59		stone feature	cairn	HRV 4	ASA 75-004
EfOn-60		stone feature	stone circle; cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-61		stone feature	cairn	HRV 4	ASA 75-004
EfOn-62		stone feature	cairn	HRV 4	ASA 75-004
EfOn-63		stone feature	cairn	HRV 4	ASA 75-004
EfOn-64		stone feature	cairn; alignment (stone)	HRV 4	ASA 75-004
EfOn-65		stone feature	cairn	HRV 4	ASA 75-004
EfOn-66		stone feature	cairn	HRV 4	ASA 75-004
EfOn-67		campsite; stone feature; workshop	cairn	HRV 4	ASA 75-004
EfOn-68		stone feature	cairn; drive lane; alignment	HRV 4	ASA 75-004
EfOn-69		stone feature	stone circle; drive lane; alignment	HRV 4	ASA 75-004
EfOn-70		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-71		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-72		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-73		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-74		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-75		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-76		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-77		stone feature	cairn	HRV 4	ASA 75-004
EfOn-78		scatter		HRV 0	ASA 75-004
EfOn-79		scatter		HRV 0	ASA 75-004
EfOn-80		scatter		HRV 0	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-81		scatter		HRV 0	ASA 75-004
EfOn-82		campsite		HRV 4	ASA 75-004
EfOn-83		stone feature	cairn; alignment (stone)	HRV 4	ASA 75-004
EfOn-84		stone feature; hunting	stone arc; blind	HRV 4	ASA 75-004
EfOn-85		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-86		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-87		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-88		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-89		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-90		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-91		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-92		campsite; stone feature	cairn	HRV 4	ASA 75-004
EfOn-93		stone feature	cairn; alignment	HRV 4	ASA 75-004
EfOn-94		campsite; stone feature; workshop	stone circle	HRV 4	ASA 75-004
EfOn-95		campsite		HRV 0	ASA 75-004
EfOn-96		scatter; stone feature ?	cairn ?	HRV 4	ASA 75-004
EfOn-97		workshop		HRV 4	ASA 75-004
EfOn-98		scatter		HRV 0	ASA 75-004
EfOn-99		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-100		stone feature	stone circle; cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-101		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-102		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOn-103		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-104		campsite	hearth	HRV 4	ASA 75-004
EfOn-105		stone feature; ceremonial	stone circle; cairn; medicine wheel ?	HRV 4	ASA 75-004; ASA CRM 090
EfOn-106		workshop		HRV 4	ASA 75-004
EfOn-107		stone feature	cairn	HRV 4	ASA 75-004; ASA 76-035
EfOn-108		stone feature	cairn	HRV 4	ASA 75-004
EfOn-109		stone feature	cairn	HRV 4	ASA 75-004
EfOn-110		stone feature	cairn; alignment (stone) ?	HRV 4	ASA 75-004
EfOn-111		stone feature	cairn	HRV 4	ASA 75-004
EfOn-112		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-113		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOn-114		scatter		HRV 0	ASA 75-004
EfOn-115	Bindloss Rock Alignment	stone feature; ceremonial	stone circle; cairn; medicine wheel ?	HRV 4	ASA 75-004; ASA CRM 090
EfOn-116		stone feature	cairn	HRV 4	ASA 75-004
EfOn-117		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-118		campsite		HRV 0	ASA 75-004
EfOn-119		scatter (lithic)		HRV 0	ASA 75-004
EfOn-120		stone feature	cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-121		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-122		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-123		campsite		HRV 0	ASA 75-004
EfOn-124		campsite		HRV 0	ASA 75-004
EfOn-125		campsite		HRV 0	ASA 75-004
EfOn-126		campsite		HRV 4	ASA 75-004; ASA 03-028
EfOn-127		stone feature	cairn	HRV 4	ASA 75-004
EfOn-128		stone feature	stone circle; alignment (stone)	HRV 4	ASA 75-004
EfOn-129		stone feature	cairn	HRV 4	ASA 75-004
EfOn-130		campsite; stone feature; natural	stone circle ?; cairn; rubbing stone	HRV 4	ASA 75-004
EfOn-131		campsite; stone feature	cairn; hearth	HRV 4	ASA 75-004
EfOn-132		stone feature	stone circle	HRV 4	ASA 75-004
EfOn-133		stone feature	cairn	HRV 4	ASA 75-004
EfOn-134		scatter		HRV 0	ASA 75-004
EfOn-135		stone feature	cairn	HRV 4	ASA 77-086
EfOn-136		stone feature	stone circle; cairn	HRV 4	ASA 77-086
EfOn-137		campsite; workshop		HRV 4	ASA 77-086
EfOn-138		stone feature	stone circle	HRV 4	ASA 77-086
EfOn-139		scatter; collection		HRV 0	Project Past 1989-1990; ASA 03 -028
EfOn-140	Hussan Corner	collection		HRV 0	TRACE 1991

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOn-141		stone feature	cairn	HRV 4	ASA 98-099
EfOn-142		isolated find		HRV 0	ASA 98-099

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOm-1				N/A	OPEN; see Site Leads File
EfOm-2		campsite		HRV 4	ASA 75-004
EfOm-3		stone feature	stone circle	HRV 4	ASA 75-004
EfOm-4		stone feature	cairn	HRV 4	ASA 75-004
EfOm-5		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOm-6		stone feature	cairn	HRV 4	ASA 75-004
EfOm-7		campsite		HRV 4	ASA 75-004
EfOm-8		campsite		HRV 0	ASA 75-004
EfOm-9		stone feature	cairn	HRV 4	ASA 75-004
EfOm-10		scatter (lithic)		HRV 0	ASA 75-004
EfOm-11		campsite		HRV 4	ASA 75-004
EfOm-12		campsite		HRV 0	ASA 75-004
EfOm-13		campsite		HRV 4	ASA 75-004
EfOm-14		campsite		HRV 4	ASA 75-004
EfOm-15		campsite		HRV 0	ASA 75-004
EfOm-16		campsite		HRV 4	ASA 75-004
EfOm-17		campsite		HRV 0	ASA 75-004
EfOm-18		campsite		HRV 0	ASA 75-004
EfOm-19		isolated find		HRV 0	ASA 75-004
EfOm-20		campsite		HRV 0	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOm-21		campsite		HRV 0	ASA 75-004
EfOm-22		campsite		HRV 0	ASA 75-004
EfOm-23		campsite		HRV 0	ASA 75-004
EfOm-24		campsite		HRV 0	ASA 75-004
EfOm-25		campsite		HRV 0	ASA 75-004
EfOm-26		campsite; quarry	hearth	HRV 4	ASA 75-004
EfOm-27		campsite		HRV 0	ASA 75-004
EfOm-28		campsite		HRV 0	ASA 75-004
EfOm-29		campsite		HRV 0	ASA 75-004
EfOm-30		campsite		HRV 0	ASA 75-004
EfOm-31		isolated find		HRV 0	ASA 75-004
EfOm-32		isolated find		HRV 0	ASA 75-004
EfOm-33				N/A	OPEN; see Site Leads File
EfOm-34		isolated find		HRV 0	ASA 75-004
EfOm-35		campsite		HRV 0	ASA 75-004
EfOm-36		campsite; killsite		HRV 0	ASA 75-004
EfOm-37		campsite		HRV 4	ASA 75-004; ASA 99-041
EfOm-38		homestead	house; barn; depression; cellar; foundation; debris	HRV 4	ASA 75-004
EfOm-39		campsite		HRV 0	ASA 75-004
EfOm-40		campsite; stone feature	stone circle	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOm-41		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOm-42		stone feature	cairn	HRV 4	ASA 75-004
EfOm-43		scatter		HRV 0	ASA 75-004
EfOm-44		stone feature	stone circle; cairn; alignment (stone)	HRV 4	ASA 75-004; ASA CRM 078; ASA CRM 090
EfOm-45		campsite		HRV 4	ASA 75-004
EfOm-46		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOm-47		scatter		HRV 4	ASA 75-004
EfOm-48		scatter		HRV 0	ASA 75-004
EfOm-49		isolated find		HRV 0	ASA 75-004
EfOm-50		campsite		HRV 0	ASA 85-005
EfOm-51		scatter (lithic)		HRV 0	ASA 85-005
EfOm-52		scatter; collection		HRV 0	Project Past 1989-1990
EfOm-53		scatter; collection		HRV 0	Project Past 1989-1990
EfOm-54		scatter; collection		HRV 0	Project Past 1989-1990
EfOm-55		scatter; collection		HRV 0	Project Past 1989-1990
EfOm-56		scatter; collection		HRV 0	Project Past 1989-1990
EfOm-57		scatter >10		HRV 0	ASA 98-099
EfOm-58		scatter >10		HRV 0	ASA 99-041
EfOm-59		campsite		HRV 0	ASA 99-041
EfOm-60		campsite		HRV 0	ASA 99-041

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOm-61		stone feature	cairn	HRV 4	ASA 99-041

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-1				N/A	OPEN; see EfOo-47
EfOo-2		stone feature	cairn; alignment	HRV 4	ASA 75-004
EfOo-3		stone feature	cairn	HRV 4	ASA 75-004
EfOo-4		campsite; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-5		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-6		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-7		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-8		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-9		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-10	Miner's #1, #2 Medicine Wheels	stone feature; ceremonial	stone circle; cairn; medicine wheel	HRV 3	ASA 75-004; ASA 76-035; ASA CRM 078; ASA CRM 090
EfOo-11		scatter; stone feature	stone circle	HRV 4	ASA 75-004
EfOo-12		scatter (lithic)		HRV 0	ASA 75-004
EfOo-13		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-14		campsite		HRV 4	ASA 75-004
EfOo-15		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-16		stone feature	cairn	HRV 4	ASA 75-004
EfOo-17		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-18		stone feature	cairn	HRV 4	ASA 75-004
EfOo-19		stone feature	stone circle; cairn	HRV 0	ASA 75-004; ASA 76-003; ASA 99 -035
EfOo-20		scatter; stone feature	cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-21		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-22		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-23		stone feature; hunting; natural	stone circle; cairn; rubbing stone; blind	HRV 4	ASA 75-004
EfOo-24	Miners #3 Medicine Wheel	stone feature; ceremonial	stone circle; cairn; medicine wheel	HRV 3	ASA 75-004; ASA 76-035; Wright, M.J. 1982; ASA CRM 078; ASA CRM 090
EfOo-25		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-26		stone feature; natural	stone circle; cairn; rubbing stone	HRV 4	ASA 75-004
EfOo-27		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-28		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-29		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-30		scatter		HRV 0	ASA 75-004
EfOo-31		scatter		HRV 0	ASA 75-004
EfOo-32		campsite; stone feature	stone circle; hearth	HRV 4	ASA 75-004; ASA 76-003; ASA 76 -065; ASA 99-035; ASA 99-122
EfOo-33		scatter; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-34	655	stone feature	stone circle; cairn	HRV 4	ASA 75-004; ASA 76-003; ASA 99 -035; ASA 99-122
EfOo-35		stone feature	cairn	HRV 4	ASA 75-004
EfOo-36		scatter (lithic)		HRV 0	ASA 75-004
EfOo-37		campsite; stone feature	stone circle	HRV 4	ASA 75-004
EfOo-38		campsite; stone feature	cairn	HRV 4	ASA 75-004
EfOo-39		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-40		stone feature	stone circle	HRV 4	ASA 75-004

ALBERTA MASTER LIST OF BORDEN NUMBERS

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-41		campsite	hearth	HRV 4	ASA 75-004
EfOo-42		natural	rubbing stone	HRV 4	ASA 75-004
EfOo-43		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-44		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-45		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-46		stone feature; ceremonial	cairn; medicine wheel	HRV 4	ASA 75-004; ASA 76-035; ASA CRM 078; ASA CRM 090
EfOo-47		stone feature	stone circle; cairn; stone line; hearth	HRV 4	Glenbow 1958; ASA 75-004; ASA CRM 078; ASA 91-092; ASA 99-007; ASA 03-222
EfOo-48		campsite; stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-49		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-50		stone feature	cairn	HRV 4	ASA 75-004
EfOo-51		scatter <10; stone feature	cairn	HRV 0	ASA 75-004; ASA 76-003; ASA 76-065; ASA 99-035
EfOo-52		scatter		HRV 0	ASA 75-004
EfOo-53		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-54		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-55		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-56		stone feature	stone circle; alignment (stone)	HRV 4	ASA 75-004
EfOo-57		stone feature; natural	stone circle; cairn; alignment (cairn); rubbing stone	HRV 4	ASA 75-004
EfOo-58		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-59		stone feature	cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-60		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-61		stone feature	alignment (stone); cairn	HRV 4	ASA 75-004
EfOo-62		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-63		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-64		stone feature; natural	cairn; rubbing stone	HRV 4	ASA 75-004
EfOo-65		stone feature	cairn	HRV 4	ASA 75-004
EfOo-66		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-67		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-68		stone feature	cairn; alignment	HRV 4	ASA 75-004
EfOo-69		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-70		stone feature	cairn	HRV 4	ASA 75-004
EfOo-71		stone feature	cairn; alignment (cairn)	HRV 4	ASA 75-004
EfOo-72		stone feature	cairn	HRV 4	ASA 75-004
EfOo-73		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-74		campsite		HRV 0	ASA 75-004
EfOo-75		workshop		HRV 0	ASA 75-004
EfOo-76		stone feature	cairn; alignment	HRV 4	ASA 75-004; ASA 76-003
EfOo-77		stone feature	cairn	HRV 4	ASA 75-004
EfOo-78		scatter; stone feature	cairn	HRV 4	ASA 75-004
EfOo-79		stone feature	stone circle; cairn	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-80		stone feature	stone circle; cairn	HRV 4	ASA 75-004; ASA 99-035
EfOo-81		stone feature	cairn	HRV 4	ASA 75-004
EfOo-82		campsite		HRV 4	ASA 75-004
EfOo-83		stone feature	stone circle	HRV 4	ASA 75-004; ASA 77-081
EfOo-84		stone feature	cairn	HRV 4	ASA 75-004
EfOo-85		stone feature	stone circle; alignment (cairn); cairn	HRV 4	ASA 75-004
EfOo-86		stone feature; homestead	stone circle; cairn	HRV 4	ASA 75-004; ASA 02-168
EfOo-87		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-88		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-89		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-90		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-91		stone feature; hunting	stone circle; cairn; blind	HRV 4	ASA 75-004
EfOo-92		stone feature	cairn	HRV 4	ASA 75-004
EfOo-93		stone feature; workshop	cairn	HRV 4	ASA 75-004
EfOo-94		stone feature	cairn	HRV 4	ASA 75-004
EfOo-95		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-96		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-97		stone feature; natural	stone circle; cairn; rubbing stone; alignment (stone)	HRV 4	ASA 75-004
EfOo-98		stone feature; hunting	arc; blind (stone)	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-99		campsite		HRV 0	ASA 75-004
EfOo-100		stone feature; natural	cairn; rubbing stone	HRV 4	ASA 75-004
EfOo-101		stone feature	cairn; alignment (stone)	HRV 4	ASA 75-004
EfOo-102		stone feature	cairn	HRV 4	ASA 75-004
EfOo-103		stone feature	cairn	HRV 4	ASA 75-004
EfOo-104		stone feature	stone circle; cairn	HRV 4	ASA 75-004; ASA 76-003; ASA 99 -035; ASA 99-122
EfOo-105		stone feature	cairn	HRV 4	ASA 75-004
EfOo-106		stone feature	cairn	HRV 4	ASA 75-004
EfOo-107		stone feature	cairn	HRV 4	ASA 75-004
EfOo-108		stone feature	cairn, stone line	HRV 4	ASA 75-004; ASA 03-351
EfOo-109		stone feature	cairn	HRV 4	ASA 75-004; ASA 76-035
EfOo-110		stone feature	cairn	HRV 4	ASA 75-004
EfOo-111		stone feature	cairn; alignment (stone)	HRV 4	ASA 75-004
EfOo-112		campsite	hearth	HRV 4	ASA 75-004
EfOo-113		stone feature	cairn	HRV 4	ASA 75-004
EfOo-114		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-115		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EfOo-116		stone feature	cairn	HRV 4	ASA 75-004
EfOo-117		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-118		stone feature	stone circle	HRV 4	ASA 75-004

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-119		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-120		stone feature	stone circle; alignment (stone); cairn	HRV 4	ASA 75-004
EfOo-121		stone feature	cairn	HRV 4	ASA 75-004
EfOo-122		stone feature	stone circle	HRV 4	ASA 75-004
EfOo-123		campsite		HRV 0	ASA 75-004
EfOo-124		campsite		HRV 0	ASA 75-004
EfOo-125		campsite		HRV 0	ASA 75-004
EfOo-126		campsite		HRV 0	ASA 75-004
EfOo-127		campsite		HRV 4	ASA 75-004
EfOo-128		palaeontological		HRV 0	ASA 75-004
EfOo-129		stone feature	cairn	HRV 4	ASA 76-003
EfOo-130	Empress Tipi Ring	campsite; stone feature; workshop	stone circle; hearth; pit	HRV 4	ASA 76-003; ASA 76-065; ASA CRM 081; ASA 99-035; ASA 99 -122
EfOo-131		stone feature	stone circle	HRV 4	ASA 76-003
EfOo-132		stone feature	stone circle	HRV 4	ASA 76-003
EfOo-133		stone feature	cairn	HRV 4	ASA 99-007
EfOo-134		campsite		HRV 4	ASA 77-081
EfOo-135		stone feature	cairn	HRV 4	ASA 77-081
EfOo-136		stone feature	stone circle	HRV 4	ASA 77-081
EfOo-137		stone feature	stone circle	HRV 4	ASA 77-081

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-138		stone feature	stone circle	HRV 4	ASA 77-081
EfOo-139		campsite		HRV 4	ASA 91-092
EfOo-140		stone feature	stone circle	HRV 0	ASA 91-092; ASA 91-104
EfOo-141		stone feature	stone circle	HRV 4	ASA 91-092
EfOo-142		stone feature	stone circle	HRV 4	ASA 91-092
EfOo-143		stone feature	stone circle	HRV 4	ASA 91-092
EfOo-144		stone feature	stone circle	HRV 4	ASA 91-092
EfOo-145		scatter		HRV 0	ASA 91-092
EfOo-146		stone feature	stone circle; cairn	HRV 4	ASA 91-092
EfOo-147		stone feature	stone circle; cairn	HRV 4	ASA 91-092
EfOo-148		stone feature	stone circle	HRV 4	ASA 91-092
EfOo-149		stone feature	stone circle; cairn	HRV 4	ASA 99-035; ASA 99-122
EfOo-150		isolated find		HRV 0	ASA 99-035
EfOo-151		stone feature	cairn; effigy ?	HRV 4	ASA 01-090
EfOo-152		scatter >10		HRV 0	ASA 01-090
EfOo-153		stone feature	stone circle; stone arc	HRV 4	ASA 01-090; ASA 04-036
EfOo-154		stone feature	stone circle	HRV 4	ASA 03-028
EfOo-155					ASA 03-028 reserved
EfOo-156					ASA 03-028 reserved
EfOo-157		stone feature	stone circle	HRV 4	ASA 03-222

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EfOo-158		stone feature	stone circle	HRV 4	ASA 04-036
EfOo-159		stone feature	stone circle	HRV 4	ASA 04-036

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EgOo-1		stone feature	stone circle	HRV 4	Mikkelborg, K. 2003

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EgOn-1		stone feature	cairn	HRV 4	ASA 75-004
EgOn-2		stone feature	stone circle	HRV 4	ASA 75-004
EgOn-3		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOn-4		stone feature	stone circle; cairn; alignment (stone)	HRV 4	ASA 75-004
EgOn-5		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOn-6		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOn-7		stone feature	cairn	HRV 4	ASA 75-004
EgOn-8		stone feature	cairn; alignment (stone)	HRV 4	ASA 75-004
EgOn-9		stone feature	stone circle	HRV 4	ASA 77-086
EgOn-10		stone feature; ceremonial	stone circle; cairn; alignment (stone); medicine wheel	HRV 4	ASA 77-086; ASA CRM 090
EgOn-11		palaeontological	bone (ungulate)	HRV 4	ASA 77-086
EgOn-12		stone feature	stone circle	HRV 4	ASA 77-086
EgOn-13		stone feature	cairn	HRV 4	ASA 77-086
EgOn-14		stone feature	stone circle	HRV 4	ASA 77-086
EgOn-15		stone feature	stone circle	HRV 4	ASA 77-086
EgOn-16		stone feature	stone circle; alignment (stone)	HRV 4	ASA 85-005
EgOn-17		isolated find		HRV 0	ASA 98-099
EgOn-18		stone feature	stone circle; cairn	HRV 4	ASA 99-041
EgOn-19		scatter <10		HRV 0	ASA 99-041
EgOn-20		scatter <10		HRV 0	ASA 99-041

ALBERTA MASTER LIST OF BORDEN NUMBERS

Feb 17, 2005

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EgOn-21		scatter >10		HRV 4	ASA 99-041

Borden No.	Site Name	Site Type	Feature	HRV	Permit No. Reference
EgOm-1		stone feature	stone circle	HRV 4	ASA 75-004
EgOm-2		stone feature	drive lane	HRV 4	ASA 75-004
EgOm-3		scatter; workshop		HRV 4	ASA 77-004
EgOm-4		stone feature	stone circle; cairn; alignment (stone)	HRV 4	ASA 75-004
EgOm-5		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-6		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-7		stone feature	stone circle	HRV 4	ASA 75-004
EgOm-8		stone feature; ceremonial	stone circle; cairn; medicine wheel	HRV 4	ASA 75-004; ASA 76-035; ASA CRM 090
EgOm-9		campsite		HRV 4	ASA 75-004
EgOm-10		stone feature	cairn	HRV 4	ASA 75-004
EgOm-11		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-12		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-13		stone feature	stone circle	HRV 4	ASA 75-004
EgOm-14		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-15		stone feature	stone circle; cairn	HRV 4	ASA 75-004; ASA CRM 078; ASA CRM 090
EgOm-16		stone feature	stone circle	HRV 4	ASA 75-004
EgOm-17		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-18		stone feature	stone circle; cairn	HRV 4	ASA 75-004
EgOm-19		campsite		HRV 4	ASA 75-004

APPENDIX I

Detailed Cost Information

TABLE I-1

RIVER PUMP STATION
Conceptual Cost Estimate
SCENARIO #1 (Diversion rate 2.0 m3/s)

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$269,000	
2	Care of water	1	L.S.	$120,000	$120,000	
3	Access Road	3	km	$100,000	$300,000	**690,000**
	Pump House					
4	Excavation	26500	m^3	$3	$79,500	
5	Compacted Structure Backfill	23000	m^3	$5	$115,000	
6	Cast-in-place Concrete for Wet Well	800	m^3	$1,150	$920,000	
7	Fish Screen facilities	1	L.S.	$600,000	$600,000	
8	Building	270	m^2	$800	$216,000	
9	Electrical	1	L.S.	$600,000	$600,000	
10	Mechanical, incl. discharge piping and surge control	1	L.S.	$500,000	$500,000	
11	Pumps, supply and install	4	each	$250,000	$1,000,000	
12	Control System and SCADA	1	L.S.	$150,000	$150,000	
13	Natural Gas supply	1	L.S.	$25,000	$25,000	**$4,210,000**
	Cast-in-place Concrete Intake Structure					
14	Cofferdam / Environmental Management	1	L.S.	$75,000	$75,000	
15	Concrete	30	m^3	$1,150	$34,500	
16	Misc. (screens, connections, backwash piping)	1	L.S.	$10,000	$10,000	
17	Riverbank Erosion Protection	1	L.S.	$300,000	$300,000	
18	Intake piping (single pipe)	200	m	$415	$83,000	**$500,000**
	Electrical Supply					
19	3-Phase high-voltage Power Supply and Transformer Sub-Station	1	L.S.	$250,000	$250,000	**$250,000**
	Total					**$5,650,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-2

RIVER PUMP STATION
Conceptual Cost Estimate
SCENARIO #2 and 3 (Diversion rate 4.0 m3/s)

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$456,500	
2	Care of water	1	L.S.	$150,000	$150,000	
3	Access Road	3	km	$100,000	$300,000	**910,000**
	Pump House					
4	Excavation	34500	m^3	$3	$103,500	
5	Compacted Structure Backfill	28500	m^3	$5	$142,500	
6	Cast-in-place Concrete for Wet Well	1100	m^3	$1,150	$1,265,000	
7	Fish Screen facilities	1	L.S.	$800,000	$800,000	
8	Building	464	m^2	$800	$371,200	
9	Electrical	1	L.S.	$800,000	$800,000	
10	Mechanical, incl. discharge piping and surge control	1	L.S.	$600,000	$600,000	
11	Pumps, supply and install	7	each	$250,000	$1,750,000	
12	Control System and SCADA	1	L.S.	$150,000	$150,000	
13	Natural Gas supply	1	L.S.	$25,000	$25,000	**$6,010,000**
	Cast-in-place Concrete Intake Structure					
14	Cofferdam / Environmental Management	1	L.S.	$75,000	$75,000	
15	Concrete	45	m^3	$1,150	$51,750	
16	Misc. (screens, connections, backwash piping)	1	L.S.	$15,000	$15,000	
17	Riverbank Erosion Protection	1	L.S.	$300,000	$300,000	
18	Intake piping (twin pipes)	200	m	$630	$126,000	**$570,000**
	Electrical Supply					
19	3-Phase high-voltage Power Supply and Transformer Sub-Station	1	L.S.	$2,100,000	$2,100,000	**$2,100,000**
	Total					**$9,590,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-3

Reservoir Supply Pipeline
Conceptual Cost Estimate
SCENARIO #1 (Diversion rate 2.0 m3/s)

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$303,000	
2	Care of water / Environmental Management	1	L.S.	$10,000	$10,000	**$310,000**
	Main Pipeline					
3	Pipe Supply : 1000mm (42") Steel	4800	m	$750	$3,600,000	
4	Installation	4800	m	$475	$2,280,000	
5	Reclamation	4800	m	$15	$72,000	
6	Cathodic Protection	1	L.S.	$20,000	$20,000	
7	Road Crossings	1	each	$10,000	$10,000	
8	Pipeline Outlet Structure in Reservoir	1	L.S.	$50,000	$50,000	**$6,030,000**
	Riverbank Construction					
10	Site Preparation	1	L.S.	$25,000	$25,000	**$25,000**
	Total					**$6,370,000**

TABLE I-4

SCENARIO #2 and 3 (Diversion rate 4.0 m3/s)

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$335,000	
2	Care of water / Environmental Management	1	L.S.	$10,000	$10,000	**$350,000**
	Main Pipeline					
3	Pipe Supply : 1200mm (48") Steel	4800	m	$850	$4,080,000	
4	Installation	4800	m	$500	$2,400,000	
5	Reclamation	4800	m	$15	$72,000	
6	Cathodic Protection	1	L.S.	$20,000	$20,000	
7	Road Crossings	1	each	$10,000	$10,000	
8	Pipeline Outlet Structure in Reservoir	1	L.S.	$75,000	$75,000	**$6,660,000**
	Riverbank Construction					
10	Site Preparation	1	L.S.	$25,000	$25,000	**$25,000**
	Total					**$7,040,000**

Note: Estimates do not include allowances for contingencies, engineering and other site investigations

TABLE I-5

Dam / Reservoir Development
Conceptual Cost Estimate
SCENARIO #1

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$515,500	
2	Care of water	1	L.S.	$50,000	$50,000	
	Sub-Total					**570,000**
	East Dam					
3	Stripping & Replacement	128,000	m^3	$3.00	$384,000	
4	Cutoff Excavation	14,500	m^3	$3.50	$50,750	
5	Random Fill	1,062,000	m^3	$2.50	$2,655,000	
6	Impervious Fill	280,000	m^3	$3.50	$980,000	
7	Gravel Surfacing	1,100	m^3	$30.00	$33,000	
8	Riprap	15,800	m^3	$80.00	$1,264,000	
9	Bedding Gravel	12,300	m^3	$30.00	$369,000	
10	Filter Drain	58,000	m^3	$35.00	$2,030,000	
	Sub-Total					**7,770,000**
	West Dam					
11	Stripping & Replacement	9,000	m^3	$3.00	$27,000	
12	Common Excavation for the Cutoff	5,500	m^3	$3.50	$19,250	
13	Random Fill	32,000	m^3	$2.50	$80,000	
14	Impervious Fill	17,000	m^3	$3.50	$59,500	
15	Gravel Surfacing	150	m^3	$30.00	$4,500	
16	Riprap	2,900	m^3	$80.00	$232,000	
17	Bedding Gravel	1,000	m^3	$30.00	$30,000	
18	Filter Drain	5,100	m^3	$35.00	$178,500	
19	Pumping Station at West Dam	1	L.S.	$200,000	$200,000	
	Sub-Total					**$830,000**
	Outlet Structures					
20	Cast-in-place Concrete	710	m^3	$1,150	$816,500	
21	1200 dia. Concrete Pipe	140	m	$1,500	$210,000	
22	Gates (1250*1250)	2	L.S.	$100,000	$200,000	
23	Gates (1250*1250)	2	L.S.	$100,000	$200,000	
24	Gate Control Building	1	L.S.	$200,000	$200,000	
25	Power Supply (single phase)	6	km	$6,000	$36,000	
	Sub-Total					**$1,660,000**
	Total					**$10,830,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-6

Dam / Reservoir Development
Conceptual Cost Estimate
SCENARIO #2

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$607,000	
2	Care of water	1	L.S.	$50,000	$50,000	
	Sub-Total					**660,000**
	East Dam					
3	Stripping & Replacement	165,000	m^3	$3.00	$495,000	
4	Cutoff Excavation	17,000	m^3	$3.50	$59,500	
5	Random Fill	1,375,000	m^3	$2.25	$3,093,750	
6	Impervious Fill	365,500	m^3	$3.25	$1,187,875	
7	Gravel Surfacing	1,200	m^3	$30.00	$36,000	
8	Riprap	17,000	m^3	$80.00	$1,360,000	
9	Bedding Gravel	13,300	m^3	$30.00	$399,000	
10	Filter Drain	62,000	m^3	$35.00	$2,170,000	
	Sub-Total					**8,800,000**
	West Dam					
11	Stripping & Replacement	14,000	m^3	$3.00	$42,000	
12	Common Excavation for the Cutoff	7,000	m^3	$3.50	$24,500	
13	Random Fill	59,000	m^3	$2.25	$132,750	
14	Impervious Fill	30,000	m^3	$3.25	$97,500	
15	Gravel Surfacing	200	m^3	$30.00	$6,000	
16	Riprap	4,600	m^3	$80.00	$368,000	
17	Bedding Gravel	1,700	m^3	$30.00	$51,000	
18	Filter Drain	7,700	m^3	$35.00	$269,500	
19	Pumping Station at West Dam	1	L.S.	$200,000	$200,000	
	Sub-Total					**$990,000**
	Outlet Structures					
20	Cast-in-place Concrete	1,060	m^3	$1,150	$1,219,000	
21	1800 dia. Concrete Pipe	160	m	$1,500	$240,000	
22	Gates (2000*2000)	2	L.S.	$200,000	$400,000	
23	Gates (1250*1250)	2	L.S.	$100,000	$200,000	
24	Power Supply (single phase)	6	km	$6,000	$36,000	
25	Gate Control Building	1	L.S.	$200,000	$200,000	
	Sub-Total					**$2,300,000**
	Total					**$12,750,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-7

Dam / Reservoir Development
Conceptual Cost Estimate
SCENARIO 3

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$705,500	
2	Care of water	1	L.S.	$50,000	$50,000	
	Sub-Total					**760,000**
	East Dam					
3	Stripping & Replacement	195,000	m^3	$2.75	$536,250	
4	Cutoff Excavation	18,000	m^3	$3.50	$63,000	
5	Random Fill	1,875,000	m^3	$2.00	$3,750,000	
6	Impervious Fill	434,000	m^3	$3.00	$1,302,000	
7	Gravel Surfacing	1,200	m^3	$30.00	$36,000	
8	Riprap	18,800	m^3	$80.00	$1,504,000	
9	Bedding Gravel	14,700	m^3	$30.00	$441,000	
10	Filter Drain	64,500	m^3	$35.00	$2,257,500	
	Sub-Total					**9,890,000**
	West Dam					
11	Stripping & Replacement	19,000	m^3	$2.75	$52,250	
12	Common Excavation for the Cutoff	8,100	m^3	$3.50	$28,350	
13	Random Fill	91,000	m^3	$2.00	$182,000	
14	Impervious Fill	45,500	m^3	$3.00	$136,500	
15	Gravel Surfacing	200	m^3	$30.00	$6,000	
16	Riprap	6,000	m^3	$80.00	$480,000	
17	Bedding Gravel	2,100	m^3	$30.00	$63,000	
18	Filter Drain	10,500	m^3	$35.00	$367,500	
19	Pumping Station	1	L.S.	$200,000	$200,000	
	Sub-Total					**$1,320,000**
	Outlet Structures					
20	Cast-in-place Concrete	1,460	m^3	$1,150	$1,679,000	
21	2150 dia. Concrete Pipe	170	m	$1,500	$255,000	
22	Gates (2300*2300)	2	L.S.	$239,000	$478,000	
23	Gates (1250*1250)	2	L.S.	$100,000	$200,000	
24	Power Supply (single phase)	6	km	$6,000	$36,000	
25	Gate Control Building	1	L.S.	$200,000	$200,000	
	Sub-Total					**$2,850,000**
	Total					**$14,820,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-8

Distribution System
Conceptual Cost Estimate
SCENARIO # 1

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$685,000	
2	Easement costs	238	ha	$1,000	$238,000	
3	Automation	1	L.S.	$300,000	$300,000	**$1,220,000**
	Secondary A1 Canal (Upper)					
4	Channel (RPE Lined) 3.25 cms - Km 0 to 3	3000	m	$600	$1,800,000	
5	Channel (RPE Lined) 3.25 cms - Km 3 to 13.3	10300	m	$330	$3,399,000	
6	Check Structures	5	each	$50,000	$250,000	
7	Farm Turnouts (canal)	17	each	$20,000	$340,000	
8	Pipeline Laterals	12000	m	$134	$1,608,000	**$7,400,000**
	Siphon					
9	Pipe (2.85 cms)	0	m	$580	$0	
10	Inlet Structure	0	L.S.	$100,000	$0	
11	Outlet Structure	0	L.S.	$100,000	$0	
12	Drain	0	L.S.	$30,000	$0	**$0**
	Secondary A3 Canal (Lower)					
13	Channel (RPE Lined) 2.85 cms	0	m	$330	$0	
14	Check Structures	0	each	$50,000	$0	
15	Farm Turnouts (canal)	0	each	$20,000	$0	
16	Pipeline Laterals	0	m	$146	$0	
17	Earth Channel Lateral (0.4 cms)	0	m	$120	$0	
18	Spillway Structure	0	L.S.	$100,000	$0	
19	Spillway Channel	0	m	$300	$0	**$0**
	Lateral Feed (A2) to Acadia Reservoir					
20	Channel (RPE Lined) 1.0 cms	5000	m	$220	$1,100,000	
21	Check or Drop Structures	6	each	$25,000	$150,000	
22	Farm Turnouts	7	each	$20,000	$140,000	**$1,390,000**
	Acadia Reservoir					
23	Pump Station (0.79 cms @ 100 psi)	1	L.S.	$425,000	$425,000	
24	Minor Reservoir rehabilitation	1	L.S.	$75,000	$75,000	**$500,000**
	Block 4 Pressure System					
25	Pipeline	16500	m	$116	$1,914,000	**$1,910,000**
	Block 3 Pressure System					
26	Pipeline	0	m	$100	$0	**$0**
	Secondary B Pipeline					
27	Pipeline	12000	m	$225	$2,700,000	**$2,700,000**
	Total					**$15,120,000**

TABLE I-9

Distribution System
Conceptual Cost Estimate
SCENARIO # 2

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$1,273,000	
2	Easement costs	389	ha	$1,000	$389,000	
2	Automation	1	L.S.	$500,000	$500,000	**$2,160,000**
	Secondary A1 Canal (Upper)					
3	Channel (RPE Lined) 6.1 cms - Km 0 to 3	3000	m	$600	$1,800,000	
4	Channel (RPE Lined) 6.1 cms - Km 3 to 13.3	10300	m	$420	$4,326,000	
5	Check Structures	5	each	$140,000	$700,000	
6	Farm Turnouts (canal)	17	each	$20,000	$340,000	
7	Pipeline Laterals	12000	m	$134	$1,608,000	**$8,770,000**
	Siphon					
8	Pipe (2.85 cms)	3200	m	$580	$1,856,000	
9	Inlet Structure	1	L.S.	$100,000	$100,000	
10	Outlet Structure	1	L.S.	$100,000	$100,000	
11	Drain	1	L.S.	$30,000	$30,000	**$2,090,000**
	Secondary A3 Canal (Lower)					
12	Channel (RPE Lined) 2.85 cms	8000	m	$330	$2,640,000	
13	Check Structures	3	each	$50,000	$150,000	
14	Farm Turnouts (canal)	20	each	$20,000	$400,000	
15	Pipeline Laterals	18000	m	$146	$2,628,000	
16	Earth Channel Lateral (0.4 cms)	4000	m	$120	$480,000	
17	Spillway Structure	1	L.S.	$100,000	$100,000	
18	Spillway Channel	4000	m	$300	$1,200,000	**$7,600,000**
	Lateral Feed (A2) to Acadia Reservoir					
19	Channel (RPE Lined) 1.0 cms	5000	m	$220	$1,100,000	
20	Check or Drop Structures	6	each	$25,000	$150,000	
21	Farm Turnouts	7	each	$20,000	$140,000	**$1,390,000**
	Acadia Reservoir					
22	Pump Station (0.79 cms @ 100 psi)	1	L.S.	$425,000	$425,000	
23	Minor Reservoir rehabilitation	1	L.S.	$75,000	$75,000	**$500,000**
	Block 4 Pressure System					
24	Pipeline	16500	m	$116	$1,914,000	**$1,910,000**
	Block 3 Pressure System					
25	Pipeline	0	m	$100	$0	**$0**
	Secondary B Pipeline					
26	Pipeline	12000	m	$225	$2,700,000	**$2,700,000**
	Total					**$27,120,000**

Note: Estimate does not include allowances for contingencies, engineering and other site investigations

TABLE I-10

Distribution System
Conceptual Cost Estimate
SCENARIO # 3

Item	Description	Quantity	Unit	Price	Cost	Subtotal Cost
	General Requirements					
1	Mob & Demob	5%	%		$1,699,500	
2	Easement costs	510	ha	$1,000	$510,000	
2	Automation	1	L.S.	$500,000	$500,000	**$2,710,000**
	Secondary A1 Canal (Upper)					
3	Channel (RPE Lined) 7.5 cms - Km 0 to 3	3000	m	$600	$1,800,000	
4	Channel (RPE Lined) 7.5 cms - Km 3 to 13.3	10300	m	$430	$4,429,000	
5	Check Structures	5	each	$150,000	$750,000	
6	Farm Turnouts (canal)	17	each	$20,000	$340,000	
7	Pipeline Laterals	12000	m	$134	$1,608,000	**$8,930,000**
	Siphon					
8	Pipe (2.85 cms)	3200	m	$580	$1,856,000	
9	Inlet Structure	1	L.S.	$100,000	$100,000	
10	Outlet Structure	1	L.S.	$100,000	$100,000	
11	Drain	1	L.S.	$30,000	$30,000	**$2,090,000**
	Secondary A3 Canal (Lower)					
12	Channel (RPE Lined) 2.85 cms	8000	m	$330	$2,640,000	
13	Check Structures	3	each	$50,000	$150,000	
14	Farm Turnouts (canal)	20	each	$20,000	$400,000	
15	Pipeline Laterals	18000	m	$146	$2,628,000	
16	Earth Channel Lateral (0.4 cms)	4000	m	$120	$480,000	
17	Spillway Structure	1	L.S.	$100,000	$100,000	
18	Spillway Channel	4000	m	$300	$1,200,000	**$7,600,000**
	Lateral Feed (A2) to Acadia Reservoir					
19	Channel (RPE Lined) 2.4 cms	5000	m	$320	$1,600,000	
20	Check or Drop Structures	6	each	$45,000	$270,000	
21	Farm Turnouts	7	each	$20,000	$140,000	**$2,010,000**
	Acadia Reservoir					
22	Combined Pump Station (1.2 cms @ 130 psi)	1	L.S.	$900,000	$900,000	
23	Minor Reservoir rehabilitation	1	L.S.	$100,000	$100,000	**$1,000,000**
	Block 4 Pressure System					
24	Pipeline	16500	m	$116	$1,914,000	**$1,910,000**
	Block 3 Pressure System					
25	Pipeline	30000	m	$275	$8,250,000	**$8,250,000**
	Secondary B Pipeline					
26	Pipeline	12000	m	$225	$2,700,000	**$2,700,000**
	Total					**$37,200,000**

TABLE I-11

ANNUAL OPERATION AND MAINTENANCE COSTS

	Scenario 1	Scenario 2	Scenario 3	
Required for entire System Development	*13600*	*22000*	*27000*	Acres
	5500	*8900*	*10850*	Hectares
Main Pumpstation at Red Deer River:				
Fixed annual electrical station charges	**$134,000**	**$251,000**	**$251,000**	
Energy costs	**$977,000**	**$1,461,000**	**$1,683,000**	
Operation and Maintenance:				
Percentage of River Pumpstation capital cost	**$156,000**	**$191,000**	**$191,000**	2.50%
Percentage of Acadia Pumpstation capital cost	**$16,000**	**$16,000**	**$31,000**	2.50%
Percentage of Supply Pipeline capital cost	**$19,000**	**$21,000**	**$21,000**	0.25%
Percentage of Reservoir capital cost	**$60,000**	**$80,000**	**$90,000**	0.50%
Distribution System based on acreage	**$204,000**	**$330,000**	**$405,000**	$15.00
Surcharge				
Required for Acadia Pumpstation	*2,500*	*2,500*	*7,500*	Acres
	1,012	*1,012*	*3,035*	Hectares
Municipal Reservoir Pumpstation:				
Fixed annual electrical station charges	**$24,000**	**$24,000**	**$39,000**	
Energy costs	**$59,000**	**$59,000**	**$147,000**	
Total Annual Operation & Maintenance	**$1,650,000**	**$2,430,000**	**$2,860,000**	

Printed: June 27, 2005

M.D. of Acadia #34
Irrigation Development Feasibility Study
Infrastructure Development
Capital Cost Estimate Summary

	SCENARIO:		
Description	**1**	**2**	**3**
Diversion and Supply:			
River Intake and High Lift Pump Station	$5,650,000	$9,590,000	$9,590,000
Power Supply (incl. sub-station)	included	included	included
Supply Pipeline to Reservoir	$6,370,000	$7,040,000	$7,040,000
Storage Reservoir:			
East Dam	$7,770,000	$8,800,000	$9,890,000
West Dam	$830,000	$990,000	$1,320,000
Outlet Structures and Miscellaneous	$2,230,000	$2,960,000	$3,610,000
Distribution System:			
Secondary A1 gravity system	$7,400,000	$8,770,000	$8,930,000
Siphon	$0	$2,090,000	$2,090,000
Secondary A2 gravity	$1,390,000	$1,390,000	$2,010,000
Secondary A3 gravity system	$0	$7,600,000	$7,600,000
Secondary B gravity pipeline system	$2,700,000	$2,700,000	$2,700,000
Secondary C pressure pipelines	$0	$0	$8,250,000
Block 4 pressure pipelines	$1,910,000	$1,910,000	$1,910,000
Acadia Reservoir Pumphouse	$500,000	$500,000	$1,000,000
Miscellaneous (mobilization, automation etc)	$1,220,000	$2,160,000	$2,710,000
Other:			
Contingencies (25%)	$9,490,000	$14,130,000	$17,160,000
Engineering Design, Geotechnical and other Site investigations	$7,120,000	$8,480,000	$10,300,000
TOTAL CAPITAL SYSTEM COST	**$54,600,000**	**$79,100,000**	**$96,100,000**
Total Irrigated Area: (ha), fully developed	5500	8900	10850
Capital Cost per hectare	$9,927	$8,888	$8,857
Capital Cost per irrigated acre	$4,017	$3,597	$3,584